The Journal

OF THE

Royal United Service Institution.

VOL. XIV. 1870. No. LVII.

RANGES, AND NOLAN'S RANGE-FINDER.

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RATHER more than two years ago, I commenced to pay a close attention to the diminution in the destructive effect of Artillery fire produced by errors in judging the range or distance of the object at which it is directed; and since that time I have tried to gather and collate the opinions upon this head, of such of my brother Officers as were willing to discuss the subject.

I have found that most Artillery Officers have pretty settled convictions upon four points intimately connected with the subject in question; they consider—

1. That when firing at an enemy, it is desirable to know how far he is off.

2. That his distance cannot be estimated by the unaided eye with a sufficient degree of accuracy.

3. That by trial shots, his range may be found, or at least closely approximated to.

4. That the rifling of guns and of small arms has somewhat changed the distances at which Artillery should act against Infantry.

When inquiries were pushed a little further, and it was asked—

1stly. What is the amount of influence that a given error in the estimation of the distance has upon the effect of the fire at a particular range; for instance, what would be the percentage of shots lost by laying the guns 50 yards wrong at 1,500 yards?

2ndly. How nearly can the ranges be estimated by the eye?

3rdly. How nearly with the aid of one, two, three, or four trial shots?

4thly. At what distances should Artillery act against the different formations of Infantry, and what limits should be prescribed to the general application of the former arm?

When any of these questions were thus definitely put, it was found difficult to elicit anything but vague replies; even the principles upon which the answers must be based, not being universally agreed upon.

This paper does not pretend to settle such questions; nay, its writer confesses to a bias in a particular direction, but it broaches them, and submits data which when supplemented, may, in abler hands, lead to their final resolution.

Query 1. *What is the amount of influence that a given error in the esti-*

mation of the distance has upon the effect of the fire at a particular range; for instance, what would be the percentage of shots lost by laying the guns 50 *yards wrong at* 1,500 *yards?*

Tables A and B have been compiled by a French Officer from the results of actual practice with the French field-piece. The 12-pounder Armstrong is more precise than the French gun of 9 centimetres, but it is improbable that the disparity is sufficiently great as to seriously affect the comparisons drawn.

The tables are only made for shot, and it might at first sight appear that they ought to have taken into account the bursting effect of shell, but in a paper opening a new subject, it would be premature to deal with the more complicated projectile; until the question had been first ventilated with regard to the simpler.

TABLE A—Showing the number of rounds per 100 which would strike a company of 34 files in line on a target 22 yards long by 6 feet 8 inches, calculated for the French Canon Rayé de 9 centimetres (the French Field Gun).

Error in estimating the range.	900 yards.	1100 yards.	1300 yards.	1700 yards.
0 yards	52·4	43·7	37·1	28·3
55 „	50·1	36·1	25	14·8
110 „	30·9	15·7	6·1	1·9

Could we, by losing a certain amount of time at the commencement, ascertain the range as closely as we would like; would it be worth our while to do so at 900 yards range?

Clearly it would be of no avail to reduce the error below 50 yards; and whether it would pay to lose time in order to keep our error limited to 50 rather than to 100, would depend, upon the amount of time expended in determining the distance, and the length of the period for which the battery would be firing upon the same point.

If we suppose that a gun fires one round in the first minute after coming into action, and two rounds in every succeeding minute, we see that it would be better to lay 100 yards wrong every time than by losing one minute to reduce the error in range to 50, or even to 20, provided the battery does not remain more than four minutes in action. After four minutes, it would produce an only equally destructive result to consume one minute in ascertaining the range within 50 yards; but it would save 40 per cent. of the ammunition. In 10 minutes, the destructive results would be much greater with a 50 yards than with a 100-yards error, even allowing for the minute sunk at the commencement.

At 1,100 yards, an error of 50 yards is of no great importance, but an error of 100 yards produces much worse practice than one of 50; so much worse, that if the battery is in action three minutes, it will be

worth while to sink one minute in determining the range within 50 yards, and at the end of five minutes, the battery having originally invested this minute, would have produced nearly double the effect of the battery firing 100 yards wrong.

At 1,300 yards, a battery expending one minute in finding the range to within 50 yards, that is, not firing its first shot for two minutes, would in its first round, produce a greater effect than a battery laying its guns 100 yards wrong which had opened its fire in one minute, and consequently had in two minutes fired three rounds.

In five minutes the former plan would produce double the effect of the latter.

At this range (1,300 yards), it becomes for the first time desirable, though still not very necessary, to reduce the error in range below 50 yards.

Even should five minutes be lost in ascertaining the range, that is, should a battery so doing not fire a round for six minutes, it would, in four minutes more, double the effect of one firing away rapidly from the commencement, and an equal total time, or ten minutes, in action, but having an error in the range of 100 yards.

At 1,700 yards, a battery keeping the error down to 50 yards, would at the first round, that is, in two minutes, double the effect of guns laid from the first, 100 yards wrong, and would have, in five minutes, a five-fold advantage.

If the range were *exactly* known, these results would be again doubled, that is, a tenfold advantage would be reaped in five minutes.

Hitherto it has been supposed that the mark fired at would be a company in line, but, from 1,700 yards upwards, it will be right to confine our attention exclusively to columns.

TABLE B—Showing the number of rounds per 100, which would strike columns calculated for the French field-piece (9 centimetres).

	Column 22 yards broad, 45 deep.				Column 22 yards broad, 110 deep.			
Error in estimating range.	1700	2200	2800	3300	1700	2200	2800	3300
0 yards	38	30·7	20·3	13·3	76·9	63	43·3	28·5
55 "	17·1	14·6	10·9	7·7	46·6	39	27·9	19·3
85 "	6·2	5·8	4·9	3·9	23·7	20·6	15·9	11·8
110 "	1·4	1·5	1·6	1·5	8·5	8	6·9	5·7

This table shows, that even at 1,700 yards, it would be quite useless to fire at a column 45 yards deep, unless the range were known to well within 100 yards, as only $1\frac{1}{2}$ per cent. of the projectiles would act, if this latter amount of error slipped in.

Eleven per cent. of the projectiles will tell up to 2,800 yards, pro-

vided the distance be known to 50 yards. At 3,300 yards, to produce the same effect, the distance must be known to within 30 yards.

French guns of position produce much better results than their field-pieces, when firing against lines of troops, if the range be moderately well known, worse (actually, not comparatively) when there is a considerable error (100 yards) in the range.

		Reducing the error of the Tangent Scale from 100 yards to 50 yards, and losing 1 minute in so doing.			Reducing the error of the Tangent Scale from 100 to 50 yds., 5 min. lost in so doing.	
		If the Battery is 2 minutes in action.	If the Battery is 5 minutes in action.	If the Battery is 10 minutes in action.	If the Battery is 10 minutes in action.	If the Battery is 20 minutes in action.
Firing at a Company	900	Is of no use.	Is useful.	Increases des. effect 50 per cent.		Increases des. effect, saves ammn.
" "	1100	Is of no use.	Is very useful.	Doubles des. effect.	Saves half ammn, des. effect same.	Increases des. effect.
" "	1300	Is very useful.	Doubles des. effect.	Quadruples des. effect.	Doubles des. effect, half ammn.	Trebles des. effect.
" "	1700	Doubles des. effect.	Increases five-fold des. effect.	Six-fold.	Quadruples effect.	
Columns 45 yards deep	1700	Quadruples des. effect.	Increases seven-fold des. effect.			

At 1,700 yards range, three French guns in position, firing at a company in line, with errors of 0, 50 and 100 yards respectively, would produce results in the proportions of 80, 25, and 1.

Strange to say, the heavier guns do not require to know the range of *columns* as accurately as the lighter pieces.

Query 2. *How nearly can ranges be estimated by the eye?*

Men totally untrained, will often judge ranges of 600 yards, 200 yards wrong, and after 1,500 yards, they seem to have lost all ideas of relative distance. Most Officers of Artillery have unconsciously trained their vision so as to be able to make a reasonable, though still very wide, guess at a range; but the Nos. 1 of guns are often deplorably ignorant, even where, as in many cases, their natural faculties for estimating distances are superior, and only require development. The extreme limit of precision which the heads of the Hythe School of Musketry claim for their pupils is, I believe, the power of judging up to 800 yards, to within one-tenth of the distance. If we extend this rule up to 1,500 yards, we should have the error of trained men at that distance, 150 yards; but the means by which the eyesight appreciates distance, are several. Many of them vary as to the distance; one—and some believe the most important—depends on the interval between the two eyes, and its power of appreciation varies as the square of the range judged; therefore, taking the limit of precision claimed at Hythe as our starting point, it may be deduced that the utmost amount of skill to which men may be trained, will lie somewhere between 150 and 300 yards at a 1,500 yards range.

Query 3. *How nearly can the range be judged with the aid of one, two, or more trial shots?*

Probably opinions on this head vary more than on any other point raised in this paper. In firing on a work where the ground in front admits of the furrows made by the projectiles which fall short being clearly distinguished by a powerful telescope in the battery, the proper angle of elevation can be attained by means of four or five careful trial shots to within 20 yards; it could be obtained exactly, only that shot out of the same gun vary 20 yards in the point on which they fall, and the error to which the gunner is thus made liable would not generally be eliminated. This error of the gun is, then, the only one which would creep into the practice.

But rapid trial shots in the field cannot be thus taken. The best quick way of obtaining them, and that usually practised, is to load all six guns with the time-fuzes set blank. The guns are fired successively, one by one, an Officer increasing or diminishing the angle of elevation according to the distance from the enemy at which he believes the last shell to have burst. When he sees a pretty good shell, the whole battery commence independent firing. The delay caused by two trial shots is about 20 seconds; but as some guns will always be loaded before others, the fire of the battery will hardly be retarded by them to that amount.

The errors in range liable to be introduced into the range on this system are evidently three: (1) the error of the gun; (2) the error of laying the apparently pretty good shell; (3) the error which the Officer directing the fire has made in judging the distance at which this shell has burst from the enemy. The first and second may be estimated at 20 yards each, which includes the differences of opinion invariably found to prevail amongst Nos. 1 as to when a gun is properly layed, and which it is impossible to eliminate. The amount of the third is, to a certain extent, an open question; but, as far as recent experiments have gone, they seem to prove that, after firing two trial shots, the distance of the third (graze or burst) from the target will be estimated 50 yards wrong, by say three men on the Shoeburyness staff, and 80 yards by the best gunners not belonging to this very select few.

The amount of this error is the only assumption made in this paper, all other statements being deduced from recorded experiments. Its truth can be easily ascertained for himself by any Officer at practice; three conditions must be studiously observed in making such an experiment.

1. The original range must be found by eye only.
2. The three rounds must be quickly fired.
3. The range sergeant must thoroughly know his work. A violation of any one of these conditions will give too favourable results.

There will then be three errors in the range when found by trial shots, the first of 80, the second of 20, the third of 20.

It is an even chance that these two last errors destroy each other; it is 3 to 1 against their both assisting to diminish the error in judging the burst of the shell; 3 to 1 against their both helping to swell that error. The net result being, that, at 1,500 yards, if the range is deter-

mined by the three trial shots, a skilful Officer will burst his shell 80 yards, over or under, the point where he would wish to burst them. Some shells will be burst nearer to this point than 80 yards, but others, to a corresponding extent, further.

Query 4. *At what distance should Artillery keep from the enemy's Infantry?*

There are some who still cling to the notion that case may be used against infantry. Formerly it was often employed successfully. *Then*, the musket was a good weapon at 100 yards, a thoroughly unreliable one at 300. Our case worked at that time very fairly up to 300 yards. *Now*, rifling and breech-loading have made the small arm at least ten times as good a weapon as it was formerly, while the rifling of our guns has slightly deteriorated our case; moreover, the diminution of our powder-charge from 2lbs. 8 oz. to 1 lb. 8 oz. has also decreased its value in the proportion of 5 to 3.

In fact, our case has, as compared with small arms, only one-twentieth of the effect it had in the Peninsular war.

A round of our case can put into a target 54 feet by 9, six balls at 350 yards; nineteen at 200. A single marksman would do more with a Snider at the longer, and half as much at the shorter range.

Case being, then, utterly contemptible when used against well-armed foot soldiers, it remains for consideration how and when shell can cope with them.

At 600 yards, a moderately skilled rifleman can put four out of half a dozen Boxer's bullets into a 6 feet target; he can fire six rounds in a minute; but when firing at that rate, say, he can only put in two per minute.

Without summoning the aid of much algebra, it may be shown that twenty riflemen would in one minute put forty bullets into a 6 feet target. A gun detachment coming into, or even in action, will present a broader and deeper mark than a 6 feet target. Allow that a want of knowledge of the range, and excitement (though this latter improves the shooting of many men) will send three-fourths of the bullets wrong, still twenty riflemen ought to plant ten bullets, or disable two horses and two men before the gun had discharged a shell. These losses would delay the opening of the artillery fire, and when it did commence, a battery filled with wounded, struggling horses, and with detachments reduced one-half, would do little harm to men lying on the ground.

What the enfield rifle can do at 600 yards, the martini-henry can do at 800; and although we may hope that the infantry of our foe will be worse armed than our own, it is only wise to calculate on its being provided with an equally formidable weapon.

At 1,100 yards, French soldiers, firing at the rate of four rounds a minute, will put 15 per cent. of their bullets into a target 6 feet 6 inches in height, by 6 yards in breadth.

A detachment of artillery may be considered about equivalent in the front it presents to infantry to a target 6 or 8 feet high, and 6 feet broad, consequently at the above rate, about 5 per cent. of the bullets would strike the gun, limber, men, or horses.

That is, if the range were known, and the infantry as cool as at target practice, 100 men would send 20 bullets a minute into the detachment. It is probable that owing to a wrong estimation of distance, &c., a large proportion of these 20 would miss in warfare, but still it must be admitted that, while such a result is not only possible but even likely, it would not only be throwing away the services of horses and the lives of men to attempt under ordinary circumstances to expose a battery to the fire of a well-armed infantry at less than 1,000 yards range, but by recklessly seeking to make an illegitimate use of artillery, to run the risk of depriving our own army of its support under conditions where its aid might be not only beneficial but essential.

Of course occasionally artillery may have to come to closer quarters, and risk everything to achieve some special object; it may be favoured by the ground, the light, the wind, or other circumstances, or like some of the Austrian cavalry at Solferino, it may be sent to draw its share of the enemy's fire.

In a work on artillery, generally attributed to the Emperor Napoleon III, it is laid down that the main effects of smooth-bore cannon in the actions fought at the commencement of this century were produced between the ranges of 700 and 1,000 yards. The principles embodied in these figures are, that artillery should not as a rule expose itself to the fire of small arms, but that outside the limit of their effective range, it should be unlimbered as close to the enemy as the ground and circumstances may admit of. In these days of marksmen, guns at 1,000 yards will be certainly nearer, in respect to the danger which their workers incur, to infantry at 1,000 yards, than were pieces in smooth-bore times at 500. 1,000 yards may then be fixed as the *lowest* limit at which guns unentrenched should oppose themselves to infantry. The higher limit will depend upon one fixed and two variable considerations, the fixed being the greatest percentage of ammunition which the artillery can afford to expend uselessly. This may be put down at 85 per cent. at the utmost, leaving 15 per cent. of effective rounds. The variable are the formation of the enemy, and the probable error in appreciating his range.

PERCENTAGE of Effective Rounds.

Error in estimating range.	Against Troops in line.					Against Troops in Columns 45 yards deep.			
	900	1100	1300	1500	1700	1700	2200	2800	3300
0	..	..	..	..	..	..	..	..	13
50	..	..	..	20	15	17	14·6	11	
75	..	..	15	10					
100	31	16							

Against troops in columns 110 yards deep.

	1700	2200	2800	3300
0				
50	..	..	..	19
75	24	20	16	12
100	8	8		

If what has been argued in points 2 and 3 of this article be allowed, namely, that by the eye, ranges can only be estimated to an error exceeding one-tenth of the distance, and by trial shots, to 80 yards at 1,500 yards, with a greater error at greater and at less ranges, we can at once see to what ranges artillery should confine itself. Judging by the eye alone, it should not fire over 1,100 yards, or as it commences at only 1,000, it would be practically useless. Judging by trial shots, it can fire against troops in line up to 1,400 yards,

against columns 45 yards deep to 1,600,
" " 110 " 1,700.

A special case may arise in which an army being encamped on a selected battle field, has roughly or thoroughly surveyed the ground in front of its entrenched batteries, so that the distances of the objects on which the guns fire are more or less accurately known. If known to within 50 yards, lines may be fired on to 1,700 yards, columns 45 yards deep to 2,200, and deep columns to 3,300; if known exactly, or within 10 yards, lines can be fired on at over 2,000 yards, and even shallow columns to 3,000.

To return to ordinary cases, the limits prescribed to a moderately rapid fire are—

1,000 to 1,400 yards against infantry in line
1,000 " 1,600 " " column.

If guns go nearer, the whole of the horses may be disabled, if they remain further, more than 85 per cent. of the projectiles are wasted.

Villages or entrenchments fired at leisurely, and where the effects are watched with powerful telescopes (not binoculars), must be considered in a totally different light.

From the foregoing considerations it is tolerably clear that any instrument which would give the range quickly and accurately, would enormously increase the power of field artillery should it fire with shot, and it is probable would multiply its powers in a still higher ratio, when using shell.

Confining (for the sake of simplicity) the argument exclusively to shot, and assuming that the error in a range estimated by trial shots is 100 yards, an instrument giving the range within one yard, and in one second, would nearly double the value of a battery firing at 1,000 yards, increase it six-fold at 1,300, and fourteen-fold at 1,700.

It is probable that such a combination of rapidity and accuracy in determining distances will never be reached, but I give the above figures to show how gigantic is the increase of destructive power, which a perfect instrument would bestow. From this it may be inferred

that a very considerable improvement of fire may result from the application of means much inferior to what I have alone defined as constituting theoretic perfection. The difference between an instrument determining ranges to within 50 yards, and such an imaginary perfect one, is from Tables A and B evidently far less than that between the imperfect instrument and the unaided eye.

The "Range-finder" which I have brought forward has no pretensions, when rapidly worked, to determine distances within a yard, or to give them instantaneously when applied to the field.* It is only claimed for it that it will determine distances to within 50 yards in a minute and a quarter at ranges not exceeding 2,000 yards, or to within 20 yards at 3,000, or 50 at 4,000, when double that time is allowed.

It is hardly necessary to more than allude to the trigonometrical process employed in finding the range by my method, as it is almost exactly that used by the surveyor.

A base is measured, and two base angles found, the only features distinguishing the plan from that ordinarily pursued with the theodolite being, that the base is very small, and the base angles never less than 80° or greater than 100°; the first condition rendering it easy to secure the second.

While the trigonometrical process is thus nearly identical with that used by the surveyor, the *personnel*, and the tools employed are very different.

A land surveyor must know a little trigonometry, and have acquired some delicacy of touch to handle a theodolite properly.

Gunners, not Officers, hardly indeed Non-commissioned Officers, are, in my belief, the only men available in action to find ranges, or, indeed, to execute any manual process; the superintendence of the fire requiring the undivided attention of the very limited number of Officers usually with a field battery.

It is needless to say that it would be impossible to teach the mass of the men the merest outlines of trigonometry.

Again, as to instruments, the various adjustments, levelling, &c., required in the theodolite are objectionable in the field.

But gunners, though not surveyors, have to point a gun, and the guns, with some additions, can be converted into first-class surveying machines, the working of which is so like the ordinary laying of the pieces, that Artillerymen can easily acquire the method.

Description of the Alterations necessary to Fit two Guns with a Pair of Range Finders.

1. A metal V should be attached to each gun, about 14 inches from the tangent-sight socket.

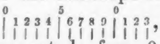
2. A second V should be provided, which can, when an occasion requires, be slipped into the tangent-sight socket.

3. One of the axletree-boxes on each gun should be removed, and a

* I have only worked out the details of a field instrument. It would give far more rapid answers used in a coast battery or ship.

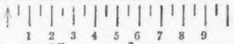
new one substituted containing an angle-measurer and a roller, and having, in a pocket on its lid, a spinning-rack, with a tape 70 yards in length.

The angle-measurer consists of—

(*a*.) A telescope with cross wires, without any focussing arrangement; the case of the telescope is turned truly round in two places to take the V's; near the eye-piece is a socket, over the object-glass; the case of the telescope is much thickened, and has graduated upon it a scale 

, the distance between 0 and 0 being eleven times repeated; from 0 to 0 is $2\frac{1}{2}$ degrees.

The telescope is made up of an eye-piece and object-glass. If the object-glass is smashed, the armourer sergeant screws in a spare object-glass. If the cross wires or any other part of the eyepiece is injured, a new eyepiece is inserted, the armourer sergeant having only to unscrew and screw, the focussing having been already done for him.

(*b*.) A short telescope, with cross wires, screwed and soldered to a limb 12 inches long, the end of this limb is marked 

so as to read on the scale of the main telescope to 45 seconds.

There are also a tangent screw to move, and a case to protect the limb, and another case with a white face to cover the short telescope; but these are minor points, "*a*" and "*b*" being the only essential ones.

The roller is a cylinder of wood, about 3 inches in height and 4 in diameter, with two movable rings, also of wood, at either end.

Its functions are to combine the angles obtained at the two guns, or the angles and the distance between the guns, so as to give the range.

It is nearly impossible to explain to any one unacquainted with the principles of mechanical calculation the means by which a mechanical calculator does its work, without actually using one in his presence, and those conversant with the use of the slide-rule can imagine how a calculation which has only one kind of sum to perform, can be constructed to furnish its results far more simply and expeditiously than the slide-rules which engineers often employ.

It will suffice to say that the circumference of one of the rings and a part of the block of the roller is divided into 100 equal parts, and will thus add together any two numbers not greater than 100 each; that there are also on the roller a scale of numbers placed apart at the distance of their logarithmic numbers, another figured so as to represent the logarithmic sines of angles; there are also other scales and artifices.

It may, at first sight, appear that all this is a scientific puzzle, intended to bewilder the mind of the gunner. But in fact, 50 gunners, at least, have learned to use it, some in ten minutes, but then they asked no questions about sines or logarithms.

To use the roller, a gunner is taught—

1stly. To bring the word "Tape," marked on the roller, under whatever number he sees on the tape (with which the distance between the guns is measured), touching the trail handle.

2ndly. To bring a mark shaped like a gun under whatever number is called out at either gun.

3rdly. To find on the roller whatever number is called out at the other gun, and to shout out the range and fuze which he finds marked over that.*

These three rules are all that the gunner need absolutely be taught; no mental calculation of any kind is demanded; he has simply to register the two first numbers he hears, and then he finds the range over or connected with the third.

Take the following example :—

The distance between the guns is $49\frac{1}{2}$ yards,

$\therefore$ Tape is set to $49\frac{1}{2}$.

19 is called out at one gun,

$\therefore$ The gun mark  is set to 19.

25 is called out at the other gun,

$\therefore$ 25 is looked at; over 25 is 44 (2), and over the corresponding $44(\frac{1}{2})$, immediately above, is 1,500 yards, the range.

Such being the instruments employed, it remains to say how they are used.

Suppose that we wish to get the distance of a horseman standing still, apparently a couple of thousand yards from the battery.

Either gun (the pivot for choice) comes into action, and when pointed roughly towards the object, the word "forward" is given. Meanwhile a gunner from the second gun has dressed himself on the wheels of the first; at the word "forward" the second gun comes into action, dressing on the gunner and pivot gun. Both guns are laid upon the horseman, first, coarsely by the sights of the gun; secondly, more finely by the cross wires of the main telescope.

As each, No. 1 covers the horseman he calls "on;" when both have thus declared they are layed, the Officer calls "halt."

The short telescopes are laid upon the opposite white faces of the cases.

The numbers pointed to by the index arrows of the limbs attached to the short telescopes are read off.

Meanwhile the distance between the guns has been measured from trail to trail.

A gunner combines with the roller the distance between the guns and the angles found, and gets the range.

If the horseman be advancing or retiring, the range will be that of the man when "halt" has been called.

Should no tape be employed, a second observation is taken at one gun upon the muzzle of its fellow; by subtracting this number from the number obtained by laying the short telescope upon the white face, the angle which the gun subtends, and consequently the distance between the guns, is found. It must not be supposed that this involves either mental or paper arithmetic; by means of a mechanical artifice the roller performs the calculation.

* To speak more precisely, there are some slanting lines, and, if the gunner needs such aid, an intermediary number, connecting the last number called out at the gun and the range.

Although the instruments I have described are intended exclusively for the field, I believe the principle to be equally applicable to coast and naval gunnery. For these cases there would be, of course, fresh difficulties to overcome; on the other hand there would not be the same absolute necessity for solidity of construction, and the base would be fixed.

Various objections have been made to the addition of a pair of my instruments to a battery. I will recapitulate such as I can call to mind.

1. The use of these instruments will add to the stores of a battery.

Answer. Granted; but the addition will be less than 1 per cent.; the increase of destructive effect claimed, is over 200 per cent.

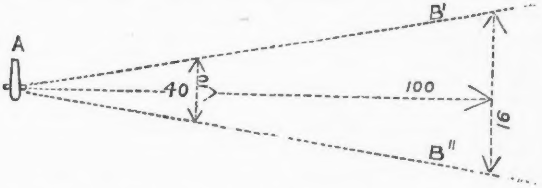
2. Four rounds less case per battery must be carried.

Answer. Case from our present field guns cannot possibly be used against infantry, and it is an open question if our carbines would not be more destructive to cavalry; tradition pointing to the case as the more useful, target practice being in favour of the small arms.

3. Two guns have to be put into certain symmetrical positions: this would be difficult to do in action.

Answer. My system on this point has often been totally misconceived by Officers watching the drill of a squad of men, and observing that the keeping certain definite distances and dressing were insisted upon. If one gun, A, is placed in any fixed position, the other, B, can be placed anywhere between the lines AB′, AB″.

I generally try to make the B″ detachment of the second gun bring it into action about x, but if by accident it should have to be



unlimbered, 20 or 100 yards, or any intermediate number of yards from A, the range can still be found.

The guns should not be more than six yards out of dressing when they are forty, or ten when they are sixty yards apart.

When it is remembered that six guns continually gallop past at a review with the muzzle of the worst dressed, not more than a foot out of line, it is hardly extravagant to hope that in a battle, two will be dressed within half a dozen yards.

4. The time lost in finding the range will make up for the increased destructive effect.

Answer. As the ammunition is carried at present, not more than half a minute will be lost; if, on the other hand, you take away preponderance, much less than half a minute.

5. Gunners will be puzzled by the figures, notably the vernier.

Answer. Four different squads have worked it successfully before Invention Committees, having on the average one Non-commissioned Officer per two gun detachments. In action there are generally four times this proportion of Non-commissioned Officers available.

TRIAL of Telemeters at Shoeburyness, 19th May, 1869, before Colonel Elwyn, R.A.

True Distance.	Errors made in Determining the Distance of a Horseman, by the instruments of			
	Adie.	Clerk.	Elliott.	Nolan.
865 yards	+ 71 yards	+ 6 yards	+ 15 yards	+ 2 yards
1200 "	0 "	+ 19 "	+ 10 "	+ 4 "
1649 "	− 19 "	+ 35 "	− 149 "	+ 15 "
1900 "	+ 12 "	+ 48 "	− 190 "	− 6 "
2558 "	+ 156 "	+ 104 "	− 158 "	− 24 "
2706 "	+ 244 "	+ 111 "	− 6 "	+ 8 "
3452 "	+ 231 "	+ 300 "	− 352 "	+ 22 "
3380 "	− 147 "	+ 217 "	− 480 "	− 26 "
3802 "	+ 164 "	+ 115 "	−1002 "	− 8 "
3040 "	− 93 "	+ 160 "	− 240 "	+ 4 "
2717 "	+ 133 "	+ 160 "	− 517 "	+ 17 "
2354 "	− 154 "	+ 84 "	− 154 "	+ 7 "
1975 "	− 95 "	+ 40 "	− 95 "	+ 25 "
1640 "	− 80 "	+ 29 "	− 120 "	+ 9 "
1205 "	+ 31 "	..	− 25 "	+ 19 "
944 "	− 8 "	..	+ 16 "	+ 6 "

On the 21st of January, 1869, a firing trial of the "Range-finder" took place upon the sands at Shoeburyness, before Colonel Wray. Two guns were worked by detachments guessing the range; the same two guns were worked by two other detachments finding the range with a "Range-finder."

Five series of four rounds each were fired, the ranges varying from 1,000 to 1,900, and averaging 1,500 yards.

The "Range-finder" guns dropped 15 shot out of 20 within 36 yards of the target, the sixteenth best being 75 yards distant.

The "guessing" guns placed 4 out of 19 shots within 22 yards, the fifth best being 59 yards distant.

During last June and July, the "Range-finder" was used to determine the ranges at Dartmoor.

As the immediate object of these experiments was to determine the relative efficiency of Shrapnell and segment shell, the trial of the "Range-finder" was not made in that strictly comparative method adopted at Shoeburyness, in which detachments with, and without, "Range-finders" were placed in otherwise analogous positions.

The Dartmoor Committee have, however, reported that they are very favourably impressed with the value of the "Range-finder." According to them, the accuracy was sufficient; the time was one

minute and a half. They recommend the experiments being prosecuted.

To this I may add that I believe I can reduce the time to one minute.

The annexed table shows the whole of the Dartmoor 9-pr. practice at targets, with one exception.

Date	Number of Rounds.	Number of hits from fragments of shell.	Average hits per round.	Average hits per round if targets are reduced to a common size.	Dimensions of targets in feet.	Rounds.	Range.
A. 30th June. Ground unknown; ranges guessed	97	118	1·3	1	54×9	2	1300
B. 30th June. Ground unknown; ranges guessed	48	255	5·4	3·6	...	2	750, 1180, 1220, 1400
C. 24th June. Ground well known; ranges guessed	108	613	6	2·3	180×9	1	800, 900, 1200, 1300, 1500, 1700
D. 1st July. Ground known; range guessed	30	419	14	10	54×9	2	900
E. 1st July. Ground known; range guessed	30	392	13	13	54×6	2	900
F. 16th June. Distance found with range finder	30	541	18	18	54×6	2	1000
G. 2nd July. Distance found with range finder	45	1205	26	26	54×6	2	1000
H. 22nd June. Distance found with range finder	45	433	10	10	54×6	2	1300
I. 23rd June. Distance found with range finder	45	446	10	9	81×9	1	1450

The practice at dummies and at earthworks is not given, as it all took place at known ranges, and is therefore useless for the purposes of comparison.

In explanation of the above table, the following remarks must be made:—

The whole of the 9-pr. practice at *targets* is given, with the exception of the first day's. The reason for omitting this is, that on that day the table of elevations was not true, and the fuze-tables for the segment-shell were extravagantly wrong. The 9-pr. practice has been tabulated, and not the 12-pr., because, although there was abundance of 12-pr. practice at known ranges, there were no returns of 12-pr. shooting at *boná fide* unknown ranges.

It has been necessary to reduce the number of hits in a separate column to targets of a common size, as the targets varied in dimensions. The principle on which the reduction has been effected is, that the number of hits will vary as the area of the targets fired at.

This principle is true in comparing vertical dimensions, that is, targets 54 feet in breadth by 9 in height ought to contain 50 per cent. more hits than targets of the same breadth but only 6 feet high. The principle is not strictly true in estimating the influence which breadth has upon the number of hits. Practically only the

series C is affected by the breadth of the targets. In its case perhaps 4 would be a fairer number for its figure of merit than 2·3.

Where several ranges are given, an equal number of rounds was fired at each range.

Series A was fired with great rapidity in three sub-series of five minutes each, at the rate of two rounds per minute. Segment shell with percussion fuzes, segment shell with time and percussion fuzes, and Shrapnell shell were employed. Men and Officers had had considerable previous practice.

B was not fired nearly so rapidly, two rounds in 2 m. 45 sec. being the average, but this included unlimbering and limbering up.

C, still slower, took over a minute a round. The ground about the targets, as well as that fired from, was thoroughly known to the Officers, having been fired over and repeatedly measured during the preceding week.

D and E were fired over ground that had been frequently traversed by Officers and men.

G and H. In this case the marks consisted of six rows of targets, but only the hits on the two front rows have been given.

F, G, H, and I were fired slowly.

I. In this case the ground in front of the targets was purposely selected, so as to be as bad as possible for the effect of projectiles. It was a true bog.

As the number of rounds given in the table was large, was fired in numerous series, under different Officers, and from six guns, chance must have been eliminated, and the table may be considered to give probabilities.

Taking, then, the average number of hits per round, reduced to a common target consisting of two rows, each 18 yards broad by 6 feet high—in fact a company of infantry—we have the following results:—

At 1,300 yards range, rapid firing at guessed ranges will give less than one hit per round; deliberate firing at a measured range, ten hits per round.

At 900 yards, careful firing at guessed ranges gives an average of 12 hits per round; deliberate firing on a measured range over 22.

It is impossible to state exactly the deductions to be drawn from B and C, as here the results of shell fired at 800 and at 1,700 yards are mixed together.

It must not be supposed that I am an advocate for slow firing; on the contrary, where the range is measured, I consider two rounds per minute the very minimum men ought to be trained to deliver, as no enemy will, if he believes his distance known, remain standing very long in the same position.

The accompanying sketch may serve to illustrate the action of the range-finder. Let C be a tree, the distance of which is required; the gun, A, is layed or pointed at this tree; the gun, B, takes up a position such that the two wheels of gun A cover each other, and is also pointed at C. The distance or base, A, and the angles, C A B, C B A, are observed.

The correct formula to determine A C would be—

$$\text{A C} = \frac{\text{A B sin. } (180^\circ - \text{A B C} - \text{B A C})}{\text{sin. A B C}} = \frac{\text{A B sin. } (\text{A B C} + \text{B A C})}{\text{sin. A B C}}.$$

But if we assume sin. A B C = unity, we will generally be very nearly always sufficiently correct.

$$\therefore \text{ A C is assumed} = \text{A B sin. } (\text{A B C} + \text{B A C}).$$

This formula is worked out by the roller on mechanical calculation.

Subjoined are the results of some official experiments made at Aldershot, in October, 1869; one of the conditions of the trial was that Lieutenant Nolan should not be present; the range-finder was worked by Lieutenant Gower, R.A.

EXPERIMENTS WITH LIEUTENANT NOLAN'S RANGE-FINDER.

Aldershot, 27th and 28th October, 1869.

Position of Battery.	Object of which range was taken.	Distance as estimated by Nos. 1. No. 1 Gun.	Distance as estimated by Nos. 1. No. 2 Gun.	Distance by Instrument.	Time.	Distance by Ordnance Survey.	Errors of Instrument.	Remarks.
		Yards.	Yards.	Yards.		Yards.		
Bench Mark, Miles' Hill ..	Wash-house chimney ..	1900	1200	2508	3·15	2470	38	Deliberate maximum time allowed 5 minutes.
" "	S.W. corner of Pavilion ..	2800	3000	2600	3·20	2630	30	Ditto ditto
" "	Flag-staff Cæsar's camp ..	3000	3000	2945	2·45	2910	35	Ditto ditto
" "	Long Hill, Bench Mark ..	1500	1300	1165	2·30	1180	15	Ditto ditto
Long Hill, Bench Mark ..	All Saints' spire	2200	1200	2363	1·20	2350	13	Against time, not more than 2 minutes allowed.
" "	Engine-house chimney, reservoir	1000	850	1328	1·15	1320	8	Ditto ditto
" "	Flag-staff Cæsar's camp ..	1900	1600	1824	1·18	1810	14	Ditto ditto
" "	Foresters' Public-house, S. corner	1100	960	1172	1·25	1160	12	Ditto ditto
N.W. corner of Pavilion enclosure	Flag-staff Cæsar's camp ..	2000	2000	1692	3·0	1650	42	Deliberately, but without using the tape.
" "	" "	"	"	1680	3·0	1650	30	Ditto but with tape.
" "	Cocked Hat Wood ..	2080	3050	2000	4·30	1970	30	Ditto without tape.
" "	" "	"	"	2000	1·15	1970	30	Ditto with tape.
" "	Wash-house	2090	6000	3655	2·45	3660	5	With tape, againgt time, but rising ground in the way. *The delay was occasioned by one of the guns coming into action out of sight of the object.*

Position of Battery.	Object of which range was taken.	Distance as estimated by Nos. 1. No. 1 Gun.	Distance as estimated by Nos. 1. No. 2 Gun.	Distance by Instrument.	Time.	Distance by Ordnance Survey.	Errors of Instrument.	Remarks.
		Yards.	Yards.	Yards.		Yards.		
Miles' Hill	Foresters' Public-house ..	1100	1100	1155	1 ·22	1160	5	At 20 yards' interval, and against time
"	Staff on Twesel Down ..	3080	4000	1640	1 ·32	1630	10	Ditto ditto*
"	N. corner of Cocked Hat Wood	1000	900	770	1 ·35	780	10	Ditto ditto
Twesel Down (very hilly broken ground) ..	S.E. do.	700	600	885	1 ·30	890	5	Ditto ditto
" "	Staff on Cæsar's camp ..	2060	2050	2115	1 ·30	2100	15	At long intervals
" "	Wash-house	4090	4080	3950	2 ·40	4100	150	Ditto deliberately
" "	Spire of All Saints' Church	3000	2100	3180	5 ·15	3140	40	Ditto very bad ground
" "	Wash-house	"	"	4050	2 ·0	4100	50	Ditto (repetition)
" "	Bench Mark on Mills' Hill	"	"	1640	..	1630	10	Ditto vide above*
Position in Long Valley ..	Waggon moving at a walk towards battery	"	"	780	..	780	0	The correct distances were subsequently ascertained by careful observation of the points placed at the spot the waggons were passing at the instant the range was taken.
" "	Waggon moving at a trot towards battery ..	"	"	795	..	797	2	
The guns to which the instruments had been attached were then trotted for four hours, subsequently the following observations were taken:—								
Long Valley	Waggon advancing at a trot	..	..	1405	..	1450	45	Measured by a chain.
Long Hill	Engine-house	..	..	1315	..	1320	5	Deliberately, and with double instrument.
"	Foresters' Public-house ..	..	..	1142	..	1160	18	Ditto ditto
"	Staff on Cæsar's Camp ..	..	..	1811	..	1810	1	Ditto ditto
"	All Saints' Spire	..	..	2349	..	2350	1	Ditto ditto
"	" "	..	..	2349	..	2350	1	Repeated, using *one* instrument only, in 3m. 30s.

Evening Meeting.

Monday, January 17th, 1870.

CAPTAIN JASPER H. SELWYN, R.N., in the Chair.

NAMES of MEMBERS who joined the Institution between the 1st and 17th January, 1870.

LIFE.

Loranie, W. C., Esq., late Indian Navy. 9*l*.

ANNUAL.

Bowman, H. S., Major late 35th Regt.
Ward, Edmund, Capt. 107th Regt. 1*l*.
Sadler, W. S., Paymaster R.N. 1*l*.
Wilkinson, E. H., Commr. R.N. 1*l*.
Cope, Edward, Lieut., Robin Hood Rifle Volunteers. 1*l*.
Rathbone, St. G. John, Ensign 1st West India Regt. 1*l*.
Simons, Alfred L., Ensign 1st West India Regt. 1*l*.
Cole, William, Lieut. 1st West India Regt. 1*l*.

STUART'S BREECH-LOADING CANNON.

By Captain GRAHAM STUART, 4th W. Y. Artillery Volunteers.

IT is my intention this evening to lay before the members of this Institution a brief description of my system of breech-loading for cannon, and to invite a full discussion of its merits as compared with those of other systems that have been introduced.

The advantages to be derived from a perfectly efficient breech-loading cannon are generally acknowledged; but the principles upon which such a weapon should be constructed have had to be evolved almost *ab initio* by a series of elaborate and costly experiments; so little was at first known of the energy of the forces that had to be dealt with. Indeed, until the commencement of that era in the history of artillery which is marked by the abandonment of the old cast-iron 32-pounder and 64-pounder guns, and the substitution of wrought iron built-up guns of far greater calibres, the powers of gunpowder were but little appreciated in their just proportion. It was about this same period that efforts were made to construct a gun that could be loaded at the breech instead of through the muzzle; the object being, at first more especially, to obtain increased rapidity of firing, and to admit of the introduction of a lead-coated projectile into the gun, of a diameter greater than the rifling (which was then what is known as *poly-grooved*) would allow. Then the difficulties that had to be encountered began to manifest themselves. It was found particularly, that to render the breech absolutely gas-tight was no easy matter, the violence of the explosion evincing such an uncontrollable tendency to force the gas between the surfaces of the breech-loading mechanism. Indeed it was not until after some time that the skill and ingenuity of Sir William Armstrong were able to master the difficulty, and to contrive a breech that would succeed in preventing the escape of gas on

the charge being exploded. But even this invention has been found to answer only for guns of the smaller calibres: when it came to be applied to cannon of the heavier descriptions its inutility for such soon became apparent, and it had to be abandoned.

But the requirements of a thoroughly satisfactory breech-loading gun do not end with the attainment of gas-tightness alone; strength and simplicity are equally essential; and though the arrangement invented by Sir William Armstrong has not failed for want of the former, the complication and delicacy of its parts have proved to be so great as to counterbalance any advantages it may possess in that direction, and preclude its recognition as a perfectly efficient system of breech-loading.

M. Krupp's guns, which have been so greatly favoured by the artillerists of the Prussian Government, are constructed, as far as their breech-loading apparatus is concerned, upon the only other system that has been, as yet, to any great extent brought into general use. His invention, however, though it may succeed in preventing gas-escape, cannot be looked upon as fulfilling the required conditions in other respects. Like Sir William Armstrong's, its component parts are too elaborate, and consequently are liable to get out of order, and so much of the breech has to be cut away for the purpose of inserting the wedge with which the breech is closed, as materially to interfere with its strength. This is so great a drawback as to form a very serious objection to the continued and general use of the gun.

One other system of breech-loading claims attention which, though not enjoying the patronage of any Government, seems to possess merits which ought earlier to have attracted more notice for it than it has received. It is that in which a sphere mounted upon an axis on which it can be partially rotated, is placed in the breech and perforated correspondingly to the bore of the gun so as to admit of the charge being passed through it into its place. This principle, one development of which is known as the Parsons gun, offers the advantages of great strength and simplicity of construction; but it has hitherto been found impossible to render it perfectly gas-tight, from there being no provision for tightening the ball in its position when the breech is closed, such as would correspond to the action of the wedge in Mr. Krupp's invention and of the breech screw in Sir William Armstrong's.

Starting, then, with an aim at obtaining the greatest strength and simplicity of mechanism, combined with perfect sealing of the breech, I have endeavoured to satisfy these requirements in the gun which I have invented, and which it is the object of this paper to describe. My attention was first directed towards the subject about four years ago; and after several attempts I at length succeeded in inventing an arrangement of the breech, which, on being practically tested, appeared to fulfil the necessary conditions exceedingly well. Since then I have been engaged in a close study of the subject, and have been able to introduce many important improvements by which I have perfected the system as now finally adopted. A system, I may add, which, when first brought out, received, even in its then imperfect state, the flattering commendation of the highest authorities upon such

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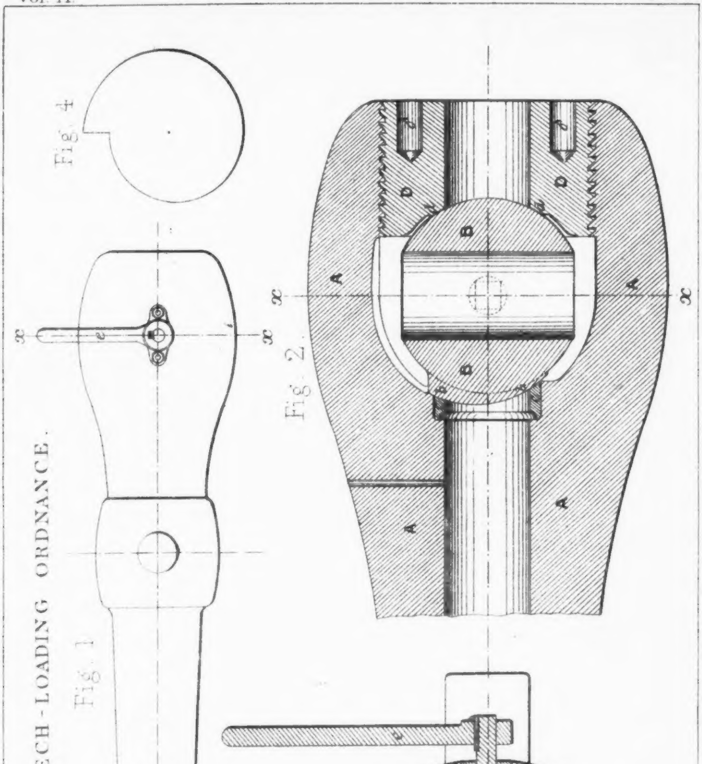
STUART'S BREECH-LOADING ORDNANCE.
Fig. 1
Fig. 2.
Fig. 3.
Fig. 4
Fig. 5.
A
B
D
E
x

J. Jobbins

matters in this kingdom, for the simplicity and ingenuity of its construction.

A gun-forging of the ordinary kind, but somewhat enlarged in the diameter of the breech, is bored as usual from end to end; but that portion of the bore lying in the breech is made from twice to three times as wide as the remainder. Into this wider part, a ball or globe is introduced, carrying on one side a projection, the surface of which has a *special section perpendicularly*. That projection fits against an expansion-ring of bronze fitted into the rear end of the bore, and when turned into position, acts precisely like a *wedge*, completely and accurately sealing the breech. The ball is perforated, so that the charge can be passed through it, into its place, and is mounted upon gudgeons which pass through the sides of the breech, and have handles attached to them on the outside of the gun, by means of which the ball can be turned on its axis through a quarter of a circle, when it is desired to open or close the breech. In rear, the ball rests against a heavy and strong breech-plug, which is firmly screwed into the solid breech of the gun. When the breech is closed, the ball, by means of its spiral or wedge-like projection, jambs itself tightly between the expansion-ring and this breech-plug, and is thus able to keep the breech perfectly gas-tight when the gun is fired. The breech-plug is also perforated similarly to the ball so that the charge is thrust through it in the operation of loading.

In order to give a clear idea of the value of the projection on the breech-ball, I desire especially to direct attention to the drawing of a spiral (Fig. 4). I endeavoured to find a figure, which instead of turning round and round, as a perfect sphere would do, would act like a wedge, and, when turned on its axis, would gradually jamb itself between the expansion-ring and the front of the breech-plug, and which, though perfectly sealing the breech when closed, would admit of its being opened with ease and rapidity. I first tried an eccentric, that is to say, a sphere whose axis of rotation did not pass through its centre of figure, but was placed a little in rear of it when in its place in the gun. This answered the purpose to some extent, but did not work so easily and "sweetly" as to be perfectly satisfactory, and after much consideration, I was at length induced to substitute what I may term a *spherical spiral* for it, which on being practically tested, I found admirably adapted to the purpose. It kept the breech perfectly gas-tight, even without an expansion-ring, and yet could be worked without the least difficulty. Now, in the first gun that I made, I carried the spiral all round the breech-globe, so that Figs. 4 and 5 would represent respectively the vertical sections taken through its centre, the one in the line of the axis of the gun and the other at right angles to it. Still there was a difficulty, which in large guns especially would have been very serious, and which, from the peculiar shape of the breech-ball seemed insurmountable. This was that it was impossible to cause it to rest against the breech-plug at the back, and consequently it could not be supported as rigidly in its place as was desirable. The whole force of the explosion had therefore to be resisted by its axles or trunnions, which, though very large and heavy cylinders of iron, would, I could

see, probably prove a drawback in applying the breech to heavy guns. I found, however, that, instead of its being necessary to carry the spiral over the whole surface of the breech-ball, it would answer every purpose if I retained only that portion of it which fitted against the bronze expansion-ring (which I then introduced for the first time) and closed up the bore of the gun. Consequently the breech-ball in Figs. 2 and 3 may be considered as a sphere turned out of the spiral-ball, Figs. 4 and 5, but having just so much of the original shape left as forms its projection *b b*. This is the shape of the breech-ball which I have now adopted, and which is used in the gun now in the Museum of this Institution. In it, all the advantages possessed by the spiral are retained in their entirety, whilst the ball can be firmly and rigidly backed up by bearing directly against the breech-plug. I desire this to be clearly understood, for I believe it to be the most important part of the invention, and that upon the shape of this breech-ball depends the whole value of the breech as one fitted for guns of all calibres.

It will be seen, then, that the breech can be opened for loading with the greatest possible ease and rapidity. Nothing has to be done but to turn the handles, *e e*, upwards through a quarter of a circle; the breech is then open. To close it, an exactly similar motion is required, but in the opposite direction. These being so expeditious and easy, the same number of gunners are not necessary to work the gun as is usually the case. Eight men are sufficient, instead of ten, and thus the opportunity of effecting a considerable financial saving is afforded. In working the gun, Nos. 2 and 3 man the handles, one on each side. They having opened the breech, No. 4, who is provided with a rammer and sponge, similar to that used with field guns, but much shorter in the staff, sponges the gun out; No. 5 then introduces the cartridge and projectile, which are supplied to him by No. 6; No. 4 rams them home (together in the case of small guns, but separately in that of large ones); the breech is closed by Nos. 2 and 3, and the gun laid and fired in the usual way.

It is evident from this, that this system affords the maximum of rapidity of fire, for it is impossible to conceive any motions for opening and closing the breech that can be more quickly performed; one only, and that a very short one, being required for each purpose. I believe I have been successful in providing satisfactorily for all the necessary requirements of an efficient system of breech-loading. The arrangement of breech I have just described has proved perfectly to meet all conditions, so far as gas-tightness is concerned. As for strength, if any openings are to be made into the breech at all, they cannot well be smaller than are those required in this instance, and therefore the strength of the breech is diminished in the least possible degree, if, indeed, practically at all. With regard to simplicity of construction, the principal parts of the breech, that is to say, those which are concerned in preventing gas-escape and resisting the force of the explosion, are but three in number, the breech-plug, globe, and expansion-ring, and their strength and simplicity are, I think, beyond question. The invention will certainly compare favourably in this respect with any of its competitors.

The superiority of my system over others consists in, first, the absolute prevention of gas-escape at the breech. This point being of vital importance, has received special attention in experimenting with the gun; but though measures were taken for the immediate detection of any escape that might take place, yet in no instance was there the slightest indication of anything of the kind having occurred: the breech proving in all cases perfectly gas-tight. Secondly, it must be considered as a matter of very great importance that no large openings have to be made in the sides or other part of the gun-breech. The prominence this assumes, arises from the fact that openings so made materially diminish the strength of the breech, and the weakness thus induced has, in other cases, resulted in the destruction of the gun from the breech being blown off by the force of the explosion. Thirdly, may be mentioned rapidity of fire, which, though not always a point of special value, in some cases becomes of great moment, when it is desirable to fire as many rounds as possible in a certain short space of time. As to the capabilities of my gun in this particular, I need only say that (without, of course, taking accurate aim) I have myself, when acting as No. 1, loaded and fired six rounds in thirty-five seconds, thus giving a rate of about ten rounds per minute; and this, too, with only four men besides myself, none of whom had previously had any regular drill or instruction in working the gun. Fourthly, the construction involves no complicated or delicate mechanism liable continually to get out of order or to be injured, from many and various causes. The whole is firm, strong, and solid, and calculated, therefore, to endure almost any amount of hard work or rough usage. Fifthly, as I said before, it requires only eight instead of ten men, a matter obviously of considerable importance when the annual cost of the maintenance of a battery is taken into account. Lastly, its manufacture is less expensive than that of other systems of breech-loading, in the proportion, according to my estimate, of from two-thirds to one-half.

A great number of experimental rounds have been fired from the gun now in the Museum of this Institution. My practice was to fire, say about 20 rounds each time, the charge being $2\frac{1}{2}$ lbs. of powder and a bolt or elongated shot weighing 15 lbs. In proving the gun, six rounds were fired with one and a-half times the above weight of powder, viz., $3\frac{3}{4}$ lbs., and a 15 lbs. bolt. In all cases the results were perfectly satisfactory, there was no escape of gas, the breech worked with ease, and no giving way could be discovered in any part of it, though, after each trial, all parts of it were carefully tested and examined by measurement and otherwise.

I have now laid before you a *resumé* of what, in my opinion, constitute the essential elements of a successful system of breech-loading for cannon, and a description of how I have endeavoured to provide for them in the gun which I have invented and patented. It only remains for me now to ask the favour of your frank opinion upon the system. Other and far greater authorities upon such subjects than I can claim to be, have expressed their high opinion of its merits, and I trust to find my hearers to-night endorsing their favourable verdict.

In conclusion, I desire to thank the President and members of this Institution for the kindness and courtesy which has permitted me to place my cannon in the Museum, and to enjoy the privilege of introducing my friends to examine it whenever I desired to do so.

EXPLANATION OF THE PLATE.

Fig. 1. Drawing of a $3\frac{1}{2}$-in. steel gun. X.X. section line of breech.
2. Vertical section of breech in the direction of the axis of the gun, on line X.X.
3. Vertical transverse section of breech, on line X.X.
4 and 5. Vertical sections of spherical spiral, illustrating the principles upon which the revolving breech-piece is constructed.

all the Figures—A The solid metal of gun.
B B Breech-ball.
b Projection of breech-ball.
C Expansion-ring, hollowed at *c*, that the explosion may drive it back against the projection.
D Breech-plug; the breech-ball rests against this at *d*. It has holes (*δδ*.) into which pegs are inserted for the purpose of unscrewing it.
E E The axles or gudgeons.
e e The handles outside gun.

The Chairman: Gentlemen, I have now to invite your discussion of the subject which Captain Graham Stuart has so ably brought before us. I have no doubt that Captain Stuart will give us any further explanation that may be thought necessary with regard to the mode in which, what we may term the spiral knob or excrescence on the breech-block rotates.

Captain Stuart: This drawing (Fig. 3, plate I) shows it better than those on the board. You will notice a vacant space cut out of the breech of the gun; a sort of gutter it may be considered. When the breech is to be opened the ball or breech block is turned one-quarter round; and the projection then comes up through that gutter to its proper position. There is another small matter connected with that which I ought to explain. Of course, when this part of the breech is in exact line with the perforation of the breech-plug and the bore of the gun, it is necessary that it should be stopped in that place; it should go exactly so far, and no farther. That object is effected by the edge of the projection coming against the breech-plug. When the perforation through the ball exactly coincides with the bore, the gun can be loaded. When the charge has been inserted, the breech-ball is turned back again, and its spiral projection jambs it tightly between the expansion-ring and the breech-plug, as I have explained above. There is a force exerted exactly similar to that which is called into action in driving a wedge into a piece of wood for the purpose of splitting it.

Mr. Macintosh: I should like to ask one question in reference to that ball. After a series of rounds, do you find any jambing from the quantity of caloric absorbed by the revolving chamber or ball? Perhaps I had better put the question in another form. Assuming that there is a greater amount of caloric absorbed by the revolving chamber, which cannot be taken up in the same ratio by the breech of the gun, is there any jambing caused thereby, or is there provision made for the expansion?

Captain Stuart: Expansion of the breech-ball?

Mr. Macintosh: Of the revolving chamber. We know that the greatest amount of heat will be evolved close to that chamber.

Captain Burgess: I wish to ask this question, viz., has the gun in the Institution, the gutter or recess for the button or knob to work in which you show in the diagram of the plans supplied by you for a 300-pounder gun; or is not the whole of the recess cut out to the depth of the breech-ball? also can Captain Stuart tell us the exact number of rounds he has fired with the gun in the Institution, and with what charges?

The Chairman: The possible future of breech-loading guns is a very interesting

subject; but those gentlemen who have followed the course of previous discussions in this Institution on the subject of breech-loading cannon will be aware that a very strong expression of opinion took place here, utterly adverse to the general tide of public opinion, which set in most unmistakably in the direction of breech-loading guns, when Sir William Armstrong first brought them forward; and that that adverse opinion was based mainly on the complication of the breech-loader, which practical artillerists took to be, and which has since proved to be, fatal to the success of these guns as military weapons. They were complicated by the necessity for coating the hard shot (which experience was teaching us required to be more attended to, to be made more tough, more carefully tempered than we had hitherto supposed to be necessary), coating this shot with a second metal, lead, in order to enable it to take the grooves of the rifle. That coating was long ago objected to in this Institution as likely to produce galvanic action. Experience was not long in proving that these anticipations were correct. Many thousands of shot were made and piled in Woolwich Arsenal and other places, which, under the galvanic action due to atmospheric influence alone, destroyed themselves, and they were condemned. Consequently, all attempts at coating iron shot with lead had to be given up. We found also that the advantages resulting in large guns, from the adoption of the principle of breech-loading, were in many cases most fallacious, and that no compensation for the increased weight and the increased necessary complication, was to be found in superior rapidity of fire, when smoke obstinately refused to clear away from before the gun. The complications, in short, whenever the guns were tried on service, proved, as Captain Stuart has said, a fatal objection to the system then adopted. But I would beg gentlemen to consider, that Captain Graham Stuart is one of those who does not despair of his gun. Like a good artilleryman, he does not, because we have been defeated in one direction in breech-loading cannon, continue to think muzzle-loading cannon a necessity, while a breech-loading rifle is an advantage. We have become so accustomed to breech-loading rifles, that we regard a man who takes a muzzle-loading rifle into the field with almost the same abhorrence that we regard the man who is ill-advised enough to take a muzzle-loading sporting gun into a battue, and to expect that others will wait for him while he loads. They have all to wait for him. But the waiting for him only delays sport; waiting for muzzle-loaders in the field may involve disagreeable consequences to those who use them. So I think we must accord the praise that is due to persevering men, to Captain Graham Stuart for telling us that there is yet hope that a breech-loading cannon may be made, and of field-piece size, especially when it is pretty well known that there would be considerable advantage, not only from the decreased number of men required to work the gun, but from the increased cover which can be obtained in the face of accurate small arms. I think we ought to accord to him our thanks for the paper he has read to us. But before doing so I will point out that in his gun, many conditions which we seek for are fulfilled. There are no wedges to be lifted out and dropped in again. The sphere which is used is part and parcel of the gun, remains as such under all circumstances; is not lifted out and *partly* dropped in again in the excitement of an action. The apparatus for checking what our American friends call the "gas-spit," or "gas escape," as we are more fond of calling it, is one which has been thoroughly proved in many instances. It is on the principle of a thimble or ring pressed back by the force of powder explosion, a self-closing wedge. I believe it to be one of the very best we can adopt. That some such apparatus is necessary is perfectly evident, when we consider the fact that the pressure requisite to drive the shot must always be exerted on the breech; and that it is perfectly hopeless to expect that so accurate a fit can be obtained as to be always gas tight, and yet not to jamb under the expansion consequent on rapid firing; for the masses of metal expand unequally, in proportion to the heat they take up. As the mass of the cannon is always much greater than that of the movable breech, so the movable breech, being in greater proximity to the charge, will take up more heat and will expand in greater degree than the mass of the gun around. Thus an absolute mechanical fit is impossible; we must compromise, we must gas-close. Then, again, there is the fact that the charge once introduced, a very simple operation for closing the breech is required, and one, in performing which, the men are not liable either to the escape of gas from too sudden firing, which often takes place in action, or to a going off of the weapon

without intention, which sometimes takes place from imperfect spongeing, or something of that nature. These men are not exposed as they would be in lifting the wedges which compose the apparatus of the Armstrong gun into and out of place. All these are essential points, and I think we have still some hope in the matter of breech-loading guns, that we may look forward to the time when our artillerymen, probably first the Artillery Association, will take up this gun and prove it. The authorities, I regret to say, appear reluctant to spend money in experiments. An inventor is often refused £100 for an experiment; and then £1,000 is expended in doing the thing, often in the wrong way. Now, this is a sad state of things, and one much to be regretted. But it is not to be expected that any Government coming into office with the amount of scientific knowledge which characterises an ordinary Government can properly take up and carry forward experiments on technical subjects at the expense of the nation, unless they be aided by some such scientific Institution as this, which may direct them in the right mode of experiments, give certificates—so to speak—to inventors, that their plans are not absurd, are worth a trial; and then the Government would be, I think, wrong indeed if it did not expend the hundreds rather than the thousands.

Lieutenant WILSON, late Indian Navy: I am aware that it is out of order to ask a question after the Chairman has made his remarks; but, perhaps, Captain Stuart will answer this question. On the explosion of the charge, the kick of the gun is imparted to the sphere, and is then again imparted to the breech screw. In your case I believe the breech is screwed into the gun. I should be glad to know if you think the thread of that screw is sufficient to withstand the explosion of the charge, or is there any escape of gas?

The CHAIRMAN: Perhaps Captain Stuart will now answer the questions that have been put.

Captain STUART: I shall have great pleasure in satisfying those gentlemen who have asked me questions respecting the gun, and I think I can satisfy them all very well. First, as to the jambing of the revolving chamber by the absorption of caloric. The very first result of the absorption of caloric by that breech-piece would be an elongation of its radii in every direction. If I understand the gentleman who asked that question, he wishes to know whether that can be brought back again to its place after it gets hot. It does not get exactly to its place, but it gets within, possibly, a hair's breadth of it. The nature of a spiral surface, being a spiral both ways, if I may so express it, is such that in closing the breech you will continually put a longer radius into the place which has been formerly occupied by a shorter (*showing*). It is a very difficult thing to conceive the figure; but the result of it is this, that both perpendicularly and horizontally, and in every possible section you can take of a figure like that, you are, in turning it round, putting a longer diameter where the short one has been before; therefore, the surfaces always fit perfectly. Where the bronze ring wears, the ball simply goes a little further round. That ring has never to be taken out when once put into its place; the revolving breech-ball simply turns a little further round, and it fits exactly as it did before. In the same way when that breech-ball is heated, it does not go quite so far as it did before, but for the reason I have already explained, the ball fits against this ring just in the same way as it did when it was cold, and keeps the gun perfectly gas-tight. With respect to the gun in the Institution, Captain Burgess has asked me whether it has that gutter cut in it. The projection in this case was so very slight that, instead of cutting a gutter, we cut it out all the way round the gun, which accounts for there not being a gutter for this gun. With regard to the number of rounds that I have fired from that gun, I cannot answer the question exactly; but I should say at least 100, at various times. The charge was the ordinary service charge, with a 15-pound shot.

Captain BURGESS: What is the gun—an 18-pounder?

Captain STUART: The gun, according to its present diameter, is a 15-pounder; when it is rifled and finished it will be a 20-pounder. I have fired charges in excess of the ordinary service charge with this gun. The first six rounds we fired with one half more powder than the ordinary service charge, in order to prove it. As to the non-closing of the breech, I would mention that in the first round that was fired from the gun, the breech was not closed perfectly, in consequence of a little

bad workmanship. The bronze expansion-ring had been pushed too far in, and the breech-ball consequently only bore against it at one point of its circumference. The result of that was, an escape of gas. We went on with our experiments, and after the first round, there was never another escape of gas.

The CHAIRMAN: Where did that escape of gas make itself felt?

Captain STUART: I had a hole bored through the top of the gun (now in the Museum) to see if any gas would escape. The first round showed that gas did escape, because it came pouring out of that hole. In the second, third, and subsequent rounds there was no escape whatever. That hole was cleaned out, and being perfectly bright, we could see after each round had been fired, if there had been any escape. When we came to take the gun to pieces we found that the ring had not been fitted accurately to its place. The first explosion had blown it back, bedded it in fact against the breech-ball, into its proper place, and after that it acted properly. So that even if the breech is *not closed* the gunners do not suffer; the only result is that the ring is forced backward, as in this instance. A gentleman asked me whether the thread of the breech-plug jambed; whether I found it strong enough to prevent jambing. I never found it jamb in the least. Of course you will remember that this breech-plug has not to be moved from its place in opening the breech of the gun. It is only taken out when it is necessary to take out the ball, and take the whole apparatus to pieces to clean it. This has been taken out, generally, after every practice. But in no instance was there the slightest difficulty in moving it round and unscrewing it when the plugs were put into these holes and a handspike put between them in the ordinary way. There never was any jambing that could be perceived, or any giving way.

Lieutenant WILSON: May I ask the depth of the thread of that screw?

Captain STUART: The depth of that is half an inch in this 15-pounder gun, and it has ten or eleven threads. In this large gun that I sent up drawings for, there is a projection also on the back of the breech-ball (I do not know whether you will be able to see it in this drawing). That projection is simply part of a larger sphere concentric with the sphere of the breech-ball. It was put there to prevent any cutting of the surface of the ball by the edge of the breech-plug against which it rests. Of course you can understand with successive explosions, it is possible that it might be damaged slightly. It might get blown against the breech-plug, and the breech-plug make an indentation in it. So in the drawings for the large gun that I sent to Woolwich, this is put in to obviate that.

Lieutenant WILSON: Did you ever fire the 15-pounder with any large excess of powder?

Captain STUART: I fired the first six rounds with half as much again as the service charge.

The CHAIRMAN: I think it only remains to give our thanks to Captain Stuart for the lucid way in which he has put the whole subject of his gun before us; and to express a hope that we may see a further development as soon as the next experimental vote is authorized. There is a point which I think ought to be adverted to: it is the extreme strength of the gun. Captain Stuart, that point in which the groove is cut, which I see in the drawing of the 300-pounder, appears to be the point of least strength. On what is that calculated? I see by the section a ring of metal left; I refer to the upper ring of the metal; the tensile strength of that is, of course, the measure of the strength of the gun, supposing an escape of gas. But you do not anticipate any such escape of gas as would bring any strain upon that. The drawing at first sight, to an engineer, suggests that difficulty. I make the observation, not that I am not satisfied myself, but I conceive an objection might be made.

Captain STUART: Every engineer has made the same objection. But there is no vertical strain when the force of the explosion arrives at this point; it is entirely horizontal; consequently, the total strength of the breech is calculated by the number of square inches in this ring of metal, independently of how they are distributed. I arrived at that strength by calculating the number of square inches in the vertical section of the powder-chamber and making the breech of such a diameter as would give its least section the same number of square inches of solid metal. When I brought this gun under the notice of the authorities at the War Office, it was so much approved of, that it was thought desirable to construct a 9-inch 300-pr. gun at

the Royal Gun Factories for the purpose of thoroughly testing its applicability to ordnance of the heaviest description. The Secretary of State for War sanctioned the making of the necessary drawings and estimates of cost for that purpose, and I was thereupon communicated with, and being requested to furnish the designs for such a gun, I forwarded a drawing of the breech to the Ordnance Select Committee at Woolwich. There it was applied to a built-up wrought-iron gun; and full-sized working drawings were sent down to me for examination and approval. I examined the drawings and returned them. The estimates were made; they were sent into the War Office, and there the matter rests for the present, the expense, as I was told last summer being so great, that at present, Government did not care to go into the matter, there being no pressing necessity for reform in the matter of heavy guns. I am, however, assured by the authorities of the War Office that they still entertain the opinion they at first formed of my breech-loader; that when the question is again gone into, it will certainly be brought forward, and will stand a very good chance of success.

The CHAIRMAN: I think this gun will be of value to Captain Moncrieff, who has been so active in bringing forward inventions, and who may desire to be able to load his guns from the rear. I hope Captain Stuart will have the pleasure of working with a brother Volunteer Officer in this direction. We return you our thanks, Captain Stuart, for your valuable paper.

ROGERS' LIFE-SAVING APPARATUS.

By Mr. J. B. ROGERS.

IN presenting to your notice this invention as a means of rendering assistance to seamen and ships in distress, I do so with the full conviction that I am supplying a *want*.

Valuable as are the methods already in use, my researches and observations upon them have convinced me that something more is still required. This is forcibly illustrated by the fact of the "Shipwrecked Mariners' Society" for so many years offering a prize for a better mode of rendering aid to shipwrecked sufferers than the existing ones. I have had the honour to receive this long-offered prize (a sum of £50), which I esteem less for its pecuniary value, than for the recognition which it accords to the utility and practicability of my invention, for the prize was not awarded to me until after I had made no less than 111 experiments, in the presence and under the superintendence of practical men. These experiments occupied a period of 12 days in the open grounds at the Crystal Palace, and were seen by thousands of persons, among whom none appeared inclined to dispute the justice of the award. This occurred at the time of the Exhibition of the Aeronautical Society. Since then I have repeated the experiments in various places, and always with success. Thus I have had opportunities of hearing the opinions and receiving the good wishes of all classes of individuals, among them, *seamen*, *gunners*, and *mechanical engineers*, who have respectively weighed the merits of the invention, each according to his own specialty, as a life-saving means—as a projectile—and as to the mechanical principles involved in its construction.

Unfortunately for the adoption of such an invention as this, it is no *individual's duty to see to it*, while at the same time to a nation such as ours, it is really *everybody's*. It is a national question, and if

I can clearly show to you the various uses to which this sure and quick means of communicating between ship and shore can be put, and of greater utility than existing modes, I trust I shall obtain your various interests in its behalf. I have done my best for this service, for I have devoted nine years of my time, sacrificed my legitimate occupation, and expended more than position warrants in order to accomplish and perfect what all practical men who have seen it agree in saying is the *best mode* of rendering aid to seamen and ships in perilous positions. If this is viewed in point of humanity—humanity is, or ought to be, one of our duties, and we cannot add to the good cause in a better way than in the preservation of life—and if we seriously consider the position of our nation, what do we not owe to our *hardy seamen*? To our *men-of-war's-men* we owe *the greatness and glory of our land.* To our *merchant sailors* we owe our *great national prosperity and our commercial position.*

Considered thus, we, more than any nation in the world are dependent upon our sailors. We owe to them honour and glory, and are indebted to them for our necessaries of life—our food—our luxuries—and our *safety*. As such, can we do too much for them? The least we can do is to provide the best means for their safety. By the preservation of the life of a sailor we may be giving the bread-winner to a family, or, as in many cases, the supporter to an aged parent. Again, the preservation of a life may be that of one the nation could not afford to lose, for men have a national value as well as a private value. To such a nation as ours this is a question of great national importance. We are, in fact, a nation in which there is hardly a family but can reckon some one of its members or friends doing duty or travelling upon the mighty ocean.

In calm weather our thoughts are upon the distant ones. But the rising winds—the sad accounts of wrecks and disasters—cause prayers to be offered up for their safety. I do not wish to be melo-dramatic upon this subject, for the papers from time to time give such accounts that very little taxing of memory will show the fearful results of wrecks, and the loss of life.

There are recorded in the *Shipping and Mercantile Gazette* of January 3rd, 1870, 2,759 wrecks as having occurred in the year 1869, and in many cases, so close to the shore that this *small model*, weighing 2½ lbs., would have been of immense assistance in the saving of life and property; for this can be propelled with certainty and precision a distance of 100 yards, conveying, as it does, a double or endless line attached, and this with the incredible small quantity of 37 grains of powder. The mortar and bed weigh only 12 lbs. One or two instances of wrecks near the shore will suffice.

The "Royal Charter" was wrecked upon the Welsh Coast, and the sacrifice of life was fearful; this was only 60 yards from the shore. The "Gossamer," was wrecked off Prowyl Point, where great sacrifice of life occurred, and this within 50 yards of the shore. I could enumerate many such cases that would forcibly show the advantage of having on board all ships such a means of communicating with the shore.

It has been a matter of curiosity to many friends, what induced me to take up this matter, for my living occupation was one in which I

had nothing to do with the sea, nor was it even a mechanical trade. The facts are: I have witnessed many wrecks upon our coast, and the feeling is most harrowing when you cannot render aid, or when it seems slow, and yet as quick as existing means will allow. My first serious attention was called to this matter on seeing an attempt to launch a life-boat from an open coast; it was only practice, not for actual service, and for over one hour were the men doing all men could do, to effect the launch by means of the outlaid warp, they were driven back upon the shore time after time. There were hundreds upon the shore, lookers on—they could render on aid.

My idea was, that if an anchor with a block and rove line could be thrown out into the sea, this immense strength on the shore, and that most willingly rendered in case of need, could be utilized. I went to model-making, and from the first of my showing till now, I have received silver medals, prizes, and such comments upon it, that I have been induced to sacrifice all other considerations to the getting this means taken up, as all agree that it is a better mode than the existing one for rendering aid to seamen and ships in distress.

My invention consists of a tri-fluked, hinged, and folding anchor, with block and endless line. (D, N Fig. 8, plate ii.) The anchor is so constructed that it can be fired from a mortar or other piece of ordnance. I have been many years mastering the details, and have made and experimentalized with innumerable forms, but found none answer so well for the purpose as the "tri-fluked" anchor, and that *hinged*, for I get the greatest amount of strength in the given form, with fulcrum and leverage. I entirely dispense with the stock for canting, as two flukes always take the ground and grip with great holding power,—by being *hinged* it is saved from coming to grief if it strikes a rock or falls upon hard substances, as may happen in being thrown from a ship on to the shore, for in that case the flukes would fold down to the blow, and be raised again directly a *strain* came upon the *main haul*. Another advantage of the tri-fluke is, if one fluke should break there are two left to take position, and gravity would be sure to so place it. In fact, it is three anchors on the one shank, and no stock required.

The block is entirely new in its construction, for it will not choke as the ordinary block sometimes does, and this block has many shore uses as well as for sea purposes, and is acknowledged by competent judges to meet a want for use in parts of rigging where blocks are subject to become fouled.

The cone which forms part of my invention is of vast consequence, for with block inserted, it would convey a double or endless line over ships in *distress*, where the anchor would not be required. Probably this would be used in fifty cases to the anchor's once, and greater distance could be attained.

I will now endeavour to show to what I owe the success of my invention as a projectile. My mortar is made with a very small chamber (I can and have used the worst form of mortar in the Service). In loading the piece after the powder, wads, &c., I use a sabôt cup, the concave of which fits the convex end of the projectile (anchor or cone), thus pre-

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Fig 1

Fig. 2

Fig 3.

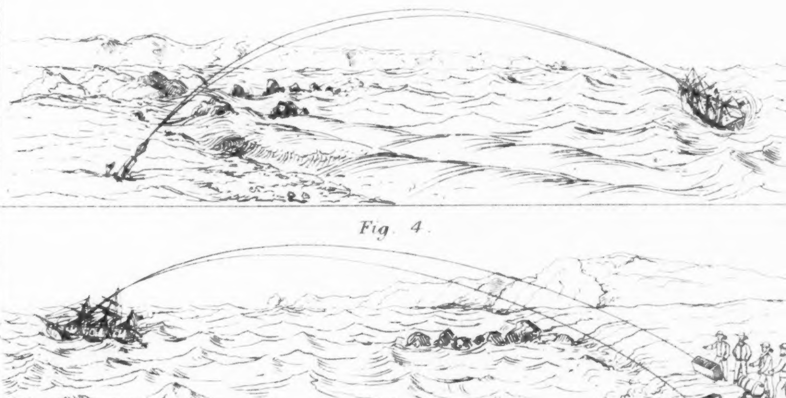


Fig. 4.

Fig 5

Fig 6.

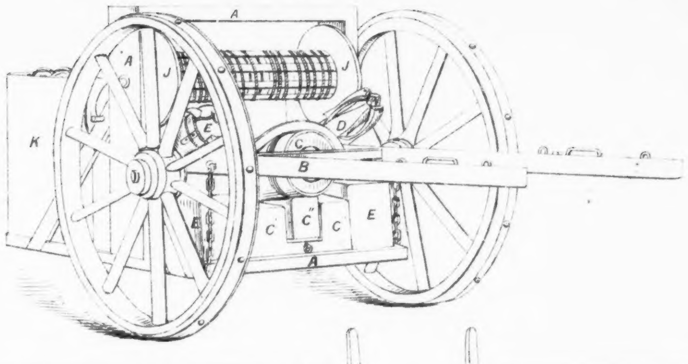


Fig 7

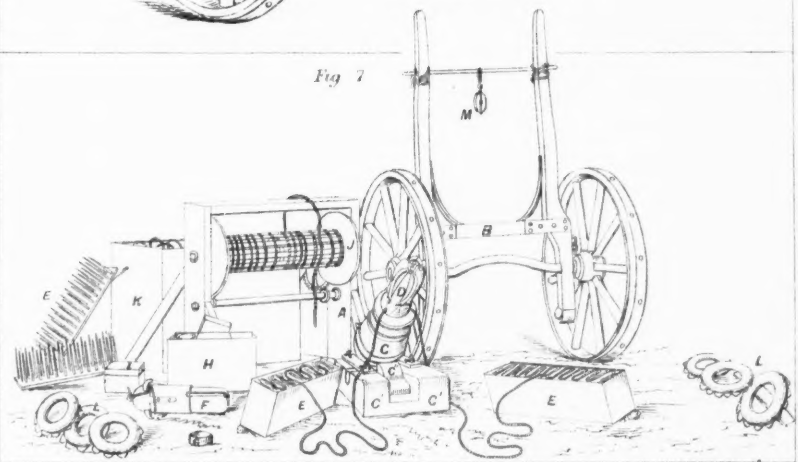
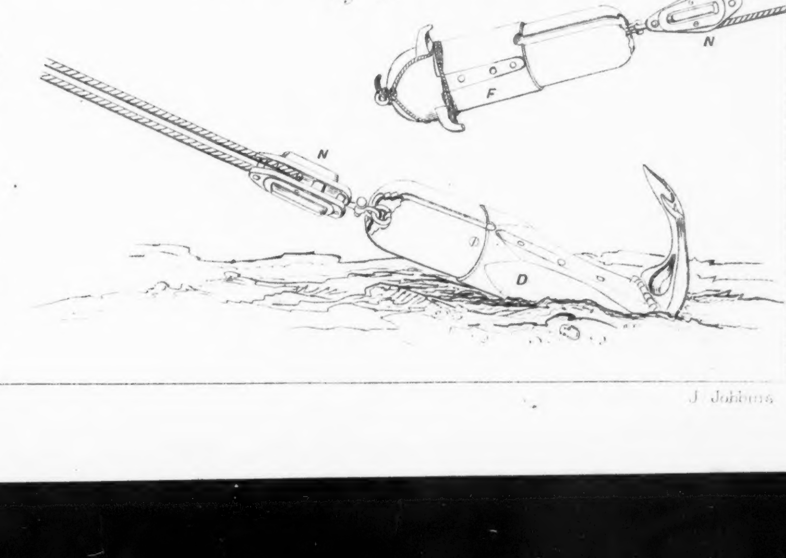


Fig 8



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serving the block inserted therein. Through this block is rove the whip or small line returning out of the mouth of the mortar and laid up in pin boxes, or faked down on the deck or beach; and so thoroughly protected are the block and lines by this means, that I have demonstrated my principle by firing *thread line* (see Plate II. for these details). Again, the use of the hinged flukes is great, for in the firing of gunpowder the effect is instantaneous. The cup sabôt receives the full blow from the charge when exploded, and flies from the mouth of the mortar some distance, protecting the block and lines from the flash of the powder. The block falls easily from the end of the projectile (anchor or cone), and being volant with the projectile, when it falls to the tautening of the chain, the flukes are hauled out, and thus acting as a check or spring, prevent the breaking of the lines.

In firing in rough weather it often occurs that a coil will get entangled and form a kink or wind knot; to an ordinary block this would be a great detriment, inasmuch as that the block would become choked and not allow the kink or knot to pass through, thus the double line would be rendered useless.

In the case of my block, such an impediment would be of no moment, as it is made to allow anything in reason to pass through it, for the sides of the block expand laterally. This expansion and the play of the upper sheave longitudinally, clear and allow what would be serious obstacles to an ordinary block to go through, and for outlaying purposes the same action of the block cuts well clear of the line. The block being so constructed to expand that while it holds the small line in position in its transit through the air, it allows a very much larger rope to pass and work freely in it when hauled off by means of the small line. The bottom sheave working upon its own centre is not interfered with in point of strength more than in the ordinary block. Thus far we have the apparatus ready for use.

The best means of transit along the coast next engaged my attention, and I have constructed a means for conveying the whole apparatus in small space for the purpose of giving aid to wrecked vessels near the shore, or for the purpose of launching lifeboats through the surf by shore aid, and without exertion to the crew where the distance is too great to be reached by a projectile.

This conveyance contains in it the "mortar," "anchor," "cone," with expanding "blocks" inserted, "two pin boxes," in which are laid up whip or small line; "large box," containing large rope or "hawser," "powder magazine," with "sabôt" case, "wads," &c., and "medicine-chest" (for resuscitating the half drowned). (Fig. 6). The wheels and shafts when erected take the place of the triangle, to bring sufferers in clear of the surf. (Fig. 7.) "Cork jackets," "basket," picks, shovel, and all appliances are also stored in or attached to the conveyance.

I will endeavour to illustrate two cases of comparison, 1st, the present mode of launching a life-boat, and the mode of launching which I propose; 2nd, the arrangement by the rocket system with its single line, and my means of communication by the double, or endless line.

The present mode of launching a life-boat is as follows. There are stationary outlaid warps at a life-boat station, and by this means the crew have to haul themselves out hand over hand, as soon as the boat is let slip from the travelling launch or life-boat carriage. They can have no assistance from the shore when they let her slip.

The merit of a life-boat is "buoyancy," which is an enemy to the launch, and the difficulty the crew have to contend with in getting the boat afloat is, that when at the expense of great exertion they get through the heavy surf and broken water, it is as *fatigued men*, when they have all the need of strength and freshness moreover to face the arduous task they have to perform. The very merit of a life-boat, "its buoyancy," is again an evil, for it is not "weatherly." These outlaid warps may not be in the best position to reach a disabled vessel, and they may be unfitted in point of strength at the time of requirement by the rolling and chafing they are subject to under water, lying out, as they do, for the season; to say the least, the wear and tear must be a serious item in point of expense.

I meet all these difficulties of launching life-boats. This, my new carriage, can be run down the coast with the life-boat carriage, where it arrives at the most advantageous point—*well to windward of the wreck.* The anchor can be fired into the sea, with a whip or small line rove through the block, one end of which would be made fast to the windlass, the other to the end of the hawser or large rope (the operation that brings in the small line carries out the large rope or hawser), which, when the end returns, is made into a round strong rope for the purpose of effecting the launch by shore aid; thus the boat could be made fast to a part of this rope, and the boat hauled through the surf by assistance from the shore without the exertion of the crew, and leave them fresh men to do their errand of mercy when they cast off and are fairly afloat.

I trust you see that I meet difficulties that really exist in this case. "for the strength of the ropes I use can at all times be depended upon." The wear and tear would only be upon the emergency of the occasion. The launch could be made at the most advantageous point to windward, and without exertion to the crew, and the launch could at all times be made, if men would dare to go; whereas many times, wrecks occur, and men are willing to venture on their merciful errand if they could only get the boat afloat; but the strength of the crew is not equal to the task. Those brave and hardy fellows do all that men can dare, but they cannot add strength to their position by the existing mode.

The means I propose gives this strength, and time would be gained when time is *life itself*, for I could get out anchor with rove *hawser* within five minutes after reaching the most advantageous point.

2ndly. The arrangement with the rocket apparatus. A rocket is fired, and carries with it a *single line only* over the *wreck*. This single line has to be hauled upon by those on board the wreck *before they can obtain the required assistance*, viz., a double line with block, and centre guide line with instructions how to work, together with a basket or other means for their safety. A rocket is a most erratic missile for aim, for it is rarely that the first, second, or third even attains the object, and I have been

given to understand that in many cases a considerable number are fired before one is successful.

I trust that you will give these points your serious and practical consideration. A vessel while *floating*, no matter how rough the weather, *gives or yields to the waves* in a measure, but as *soon* as she strikes upon shore there is no more life—all being dead in her as a vessel—no more buoyancy—she becomes entirely at the mercy of the raging sea. She either drives further on to the shore, or becomes, as it were, a *solid mark* for the waves to spend their rage upon. The men no longer have the use of their legs, but it is "everyone for himself" to hold on, or make fast, to gain security from being washed overboard—some in the fore part, some amidships, and others aft of the doomed ship, and in cold and wintry weather all soon become benumbed and nearly helpless. I wish this to be distinctly understood, for allowing the rocket line to be got over the ship at the first fire, the men have to get together and haul upon the single line before they can obtain relief, the vessel being all this time at the mercy of the heavy waves; when at last they obtain this double line, the means so obtained is good and efficient, but the fact is clear that they must first do a heavy part of the work themselves.

By my method I run my carriage to the place of wreck, and fire a cone, upon which are instructions for its use, painted in various languages. In the end of this cone is my unchokable block, through which is rove a whip or small line, giving the double line at once, requiring no labour from the benumbed and scattered sufferers, as any one it falls near to, can make it secure; then I can render all the aid required from the land upon this whip-line. I pass away the large rope as in the case of the launch (with centre line for basket if necessary), or cork jackets could be passed out on the windward line; when they came up to the wreck they would be released and fitted on to the sufferers, they then making themselves fast to the lee side of the line, so that while a continual stream of life-belts or other means were being conveyed out on the windward line, a continual stream of life could be brought ashore on the lee line. When they got near the surf they would be hauled up clear of the beach, as the shaft of the carriage could be rigged up for that purpose. (M Fig. 7.) The accuracy of aim with my cone is allowed to be excellent: in the hands of a practical gunner the aim is certain; this cannot be said of the rocket at any time or in any hands.

In giving this brief detail of the two principal uses of my apparatus, I trust that it can be seen that the arrangement would be serviceable in many other cases. When used on board ship, the anchor, cones, with blocks inserted, mortar, and pin-boxes, would be the only requirement, and as all ships are bound to carry a signal gun, the mortar would answer that purpose, as well as being an aid in itself.

I have lately made a series of experiments by order of the Lords Commissioners of the Admiralty (with projectiles made in Her Majesty's Dockyard, Portsmouth), on board Her Majesty's gunnery ship "Excellent," Captain Boys, R.N. On the 7th of December, 1869, I used cones, of which this is one. The weight is 12 pounds. I propelled this cone from

a mortar of $3\frac{1}{2}$-inch bore (weight of which with bed is under 2 cwt., *and it was the very worst* form of mortar in the Service for my purpose), a distance of 198 yards, with $1\frac{1}{2}$ ounce of powder, conveying with it a $\frac{1}{2}$-inch endless or double whip-line. There was half a gale blowing at the time, so that about 450 yards of line were carried out; these lines would have been a fair lead for a larger rope.

I will not occupy your valuable time with details of that series of experiments; suffice it to say that several shots were fired, and all with success, great precision was noted, and the lines in all cases were free to work.

My large anchor was finished, and I had a preliminary trial on the 6th of January, 1870. This is the first time that *such a weight*, in such a form, had ever been thrown from a mortar. I had a cone made of nearly the same weight in order to test the flight before trying the anchor.

The mortar I used was an 8-inch one, and this had not seen service for 10 or 12 years.

The first shot was from this mortar with a cone weighing 124 lb., the quantity of powder, 4 ounces, large grain, elevation 45 degrees, distance 64 yards, direction accurate, the lines, block, and all worked well and free; sabôt not broken.

The second shot was with the same cone; 8 ounces of powder, large grain; distance 87 yards; elevation 45 degrees; direction accurate, block jammed in, but worked free to lead; the cause of this was that the metal case was of *brass*, it should have been of iron, and a little thicker, to meet the first blow. Still everything worked freely. Admiral Cooper Key, Captain Boys, R.N., Lieutenant Steward, R.N., of H.M. gunnery ship "Excellent," Captain Tucker, R.N., and Captain Morris, of Lloyd's, Captain Pain, and several other gentlemen investigated the cause of the fracture, and this is the form now recommended to be used (pointing). In order to strengthen the stern of the projectile to meet the first blow instead of having its form hemispherical to have it straighter and flatter; not to have the cup so deep in form as this, because, if the projectile should happen to be weighty, the cup might act as a wedge; and whereas my rope, returned out of the mouth of the mortar, is turned up very sharp, it is suggested to have a wider groove on the sides of the projectile, still of the same depth, but not with so sharp a turn.

Third shot.—The weight of anchor was 134 lb.; powder charge 12 ounces; distance obtained 142 yards 2 feet, elevation 37 degrees, flight allowed by all to be surprisingly accurate (1-inch line used in all cases). The weight of line with this shot was allowed to be about 75 lb. The same fault with the block, viz., it jammed in the end from the same cause; it requires simply to make the end of iron, and a little stouter to meet the first concussion. The sabôt was picked up whole. The block was not injured but only jammed in; it could, however, have been used at once had it been a case of emergency.

There was nothing injured, and the projectile could have been returned and fired again, then and there. It was the first preliminary trial, and as such was looked upon as a great success.

In firing in my way, it is necessary to understand the means by which the double line is carried. In all cases, I use a little stronger line for the first connection, a fathom or a couple of fathoms of line, to take the first bearing. Innumerable materials have been tested for firing. Some have recommended wire, others rope, others chain, but I find good whale-line the best, if you have something to prevent it catching fire. It is very necessary that the lines should be put well in front. In carrying the lines, the block travels for some little distance, protected by the sabôt, which also protects them from fire. It falls away some twenty yards in advance of the mortar. Then, with the tightening of the line, the block is dragged out, and that, acting as a check or spring, prevents the breaking of the line, by lifting the flukes of the anchor. In all cases the flukes travel open during the flight without rotary motion. That was a thing I feared, and I therefore allowed for swivelling, but I found it was not necessary. The only chance of its getting rotary motion is when it happens to fall upon the ground, and in that case it may roll over. But I find I get no rotary motion in travelling. The sabôt cup takes the whole blow of the charge. I wish it to be understood that in firing a single line the crew have to haul a single line to themselves before they can obtain the required assistance. In my case, I throw a cone, not an anchor, over a ship. I obtain, of course, a greater distance with the cone than with the anchor.

In the experiments which I made at Portsmouth, I should never have dreamt of having a cone of 124 lb. weight. I could get no reliable information as to what the result would be of throwing so heavy a weight as was required in the anchor for test from a mortar, therefore I had a cone made as nearly approaching the weight as I could, to see what the result would be. But in case of firing from an 8-inch mortar, I should never think of throwing more than a 50 lb. or a 60 lb. projectile-cone. It would carry that, and would also carry a sufficient weight of line; and instead of getting 142 yards with 12 oz. of powder, the probability is, I should get 400 or 500 yards, judging from what I have obtained with these models of cones, with smaller charges. In firing over a vessel in distress, I throw a double line with a cone at the end. The crew would merely have to make the cone fast (the head of the cone carries a lashing sufficient for the purpose), so that a turn inboard could be taken to the best place the crew could make fast to. It would be hauled back by shore aid if it went too far over. There is no anchor grip to this cone, so that it could be hauled back again. As soon as there is sufficient line thrown to go over any part of the vessel, the men could easily get hold of it. Supposing the cone got thrown over a broken mast, the friction would be great upon the rope, but I find sailors are a most ingenious set of men for working out of a difficulty if they get into one. Give them the two ends of a rope, and I have no doubt they would know what to do with them.

I will now state in conclusion a few uses to which my apparatus could be applied; practical minds might find other ways to make it of practical utility.

For assisting in launching boats through surf or heavy water to or from the shore.

For getting a boat away from a ship's side when she is lying at anchor in a roadstead, thus preventing many accidents which occur from boat stoving.

For getting out an anchor by boat service, or by means of raft when it would be difficult and dangerous to get out boats without such means, and the extra spring out by this arrangement might be the saving of vessels and crews in critical positions.

For ships to make communication with the shore in cases of danger; a vessel may be dragging her anchor, but by this arrangement she could pass her crew, &c., safe to shore, when there is no assistance to be rendered from the shore, as in uninhabited parts of the coast, at home or abroad.

In the case of a wreck under a cliff, bluff or headland, the anchor could be fired over and the crew passed up by the lines, when no boat could live to render aid.

One vessel might give aid to another in perilous positions by means of cone and block when it would be highly dangerous to lower a boat or go too near to render aid.

For throwing an endless chain, with grapnel and block, over high buildings, in case of fire, where ladders will not reach.

In war time, a vessel feeling her way up a river might make sure by this means of clearing her way of torpedoes.

It might be fired on board an enemy to hamper her, so as to gain an advantage of position.

For getting pontoon-bridges over rivers; the pontoons could be built under cover and run over, not a man being seen.

For passing ropes over ravines, or for scaling heights, or for running up ladders for scaling, &c.

In general the cone is to be used where assistance is to be had; the anchor and block, where there is no aid.

Mr. Rogers then proceeded to exhibit the mode of working his apparatus, in throwing the lines out and making them secure to a ship in distress, and he also showed how the shafts of the cart could be made available in drawing the crew on shore above the reach of the surf.

DESCRIPTION OF PLATE II.

Fig. 1 shows the act of firing the anchor into the sea, with block and double whip-line.

Fig. 2. Lifeboat being launched by aid of the outlaid anchor, &c., after the whip-line has been fair lead for hawser or stouter rope. The launch being effected by people on the shore, requires no exertion on the part of the crew until they are well clear and cast off.

Fig. 3. The anchor, block, and whip-line thrown from a wreck to the shore where there is no one to give assistance. I would recommend in this case a volunteer to be sent on the rove-line so as to see all fair and fast before boat service is used.

Fig. 4. Throwing the cone, block, and rove-rope over a wreck from the shore, thus showing the time saved over the existing mode of throwing single line by rocket, &c. (all the aid being given from the shore).

Fig. 5 shows how lines can be thrown over ravines by armies on line of march, being first communication for making a temporary bridge. For uses see paper.

Fig. 6 shows the conveyance for all the necessary appliances for launching boats from the beach, or rendering aid by means of lines thrown over wrecks near the shore.

Fig. 7 shows the appliances detached. AAA. The frame (which can be made of light iron). BB. Carriage (erected with block to bring crew of ship-wrecked vessel clear of the surf). C. Mortar. C′. Bed. C″. Quoin. D. Anchor. EE. Pin boxes (with lines faked down ready for use). E′. The pins taken from boxes. F. Cone (with line to head to make fast). G. Sabôt. H. Magazine and sabôt case. I. Medicine chest. JJ. Windlass (for drawing in the whip-line and paying out the hawser). K. Hawser box. LL. Life buoys. M. Snatch-block (to reeve line in).

Fig. 8. F. Cone with block, N. and rove-rope. N. N. Front and side view of unchokable block. D. Anchor with block and rove hawser.

The CHAIRMAN: I invite discussion on this subject, most interesting to all who have anything to do with the profession of the sea.

Lieutenant WILSON (late Indian Navy): About two years ago I was a member of the Committee of the "Salvage Association at Lloyd's," appointed to inquire into this very subject. I have not seen anything of it from that day to this. Several suggestions were made at the time, which I see Mr. Rogers has carried into effect, particularly in the shape of the anchor fluke. At the time a very favourable opinion was formed of the apparatus; it is certainly worthy of our favourable consideration, seeing that he has made many experiments since then, which have been attended with a considerable amount of success. I think the arrangement of the block is particularly ingenious.

Captain BURGESS: Are all the anchors which you use of the form shown to us this evening?

Mr. ROGERS: I make the anchor-flukes of different shapes. If it is for use where the ground is hard, I make the flukes shorter. This fluke can be made to suit any ground.

Mr. JAMES CROSSLAND, (Assistant Constructor of the Navy): I should like to know what is the weight of the cone usually employed?

The CHAIRMAN: If you were to state the different weights in proportion to the distance, it would be most instructive.

Captain BURGESS: Will you be good enough to tell us what the scale of the cart before us is, and what would be the weight of the hawsers which you propose to carry?

The CHAIRMAN: Mr. Rogers will understand the latter question as applying to the total weights which he proposes to add to the draught, the lifeboat itself having to be carried down, so as to give us an idea of what might be the increased power required, or the increased appliances, in order to get the lifeboat and the mortar, ropes, &c., into difficult situations.

Lieutenant WILSON: I may say that it would have been very desirable had there been some one present from the Lifeboat Institution, or the Board of Trade, to tell us how far they throw their single line, because I understand Mr. Rogers claims to throw his double lines much further.

The CHAIRMAN: That is an important point.

Mr. ROGERS: The shape of the anchors could be anything to suit the anchorage ground. The weight of the anchor I have thrown up to the present time has been 134 lbs., which I consider far too heavy for the purpose, to be thrown from the mortar. Two flukes, as you notice in my models, always take, so that I get a double grip. The length of the flukes I used for the 134 lb. anchor was 1 foot 3 inches; each fluke from the joint there, would grip.

The CHAIRMAN: From the crown?

Mr. ROGERS: No; not from the crown. I am reckoning from where the grip would actually be. Gentlemen present may not have noticed the shape of the hinge of this anchor. The weight of the anchor for getting a lifeboat afloat I think would

be about 80 lbs.; that would be ample for the purpose, as the greater part of the weight of my anchor is in the crown. The scale of the cart before you is three inches to the foot; the full-sized apparatus, not reckoning the length of the shafts, would be about 4 feet by 6 feet, to convey the whole of the appliances, which would be a mortar (a 6-inch mortar would be ample for the purpose), the rope, a 3-inch whale line, which would be ample, I think, to haul the lifeboat through any surf. If you have a lighter line you would require a larger circumference, but you would not have strength. With a 3-inch whale-line you get compactness. You might have metal rope, which would take less bulk, but it would have greater weight, I fear. The cart must be a separate and distinct conveyance from the lifeboat launch. I do not think that we could arrange for the same horses which draw the lifeboat launch to convey the cart as well. In reply to another question I would say that there is no such thing as throwing an anchor into the sea with a double line. Captain Jerningham, R.N., made many attempts, successfully at times, to throw an anchor into the sea with a single line attached. Where I think he failed was through putting his anchor into the mouth of the piece, crown first. His line was made fast to the anchor outside the mouth of the piece, but directly it left the mouth it had to turn, and that gave the line such a sudden snatch, that it invariably broke, so I am given to understand. This is how I overcome the difficulty of breaking my line: it being volant with the projectile, and being rove through the block which is in the stern of the anchor, it drops easily from it, and it has no weight to snatch at. I think an anchor weighing something like 80 lbs. would do, but that I leave to practical men to say. The only thing I can say is that I have thrown a 134 lb. anchor from an 8-inch (ordinary Government pattern) mortar. That seemed to me to have the holding power necessary for hauling a 500-ton ship.

Captain BURGESS: What range did you get?

Mr. ROGERS: I have fired that anchor 142 yards, at an elevation of 37 degrees, carrying a double line very well with it. I have obtained a greater distance and accuracy with these cones [pointing to some 12 lb. projectiles] than was ever obtained with a rocket. From enquiries made of practical men, I am given to understand that the rocket, which costs a *guinea*, will make fair firing at from 70 to 100 yards, but over 100 yards you must not depend upon it. It will, at times, attain 150 and 175 yards. I have thrown that cone (the 12 lbs.) 198 yards (from a 3½-inch mortar, which, with bed, weighed under 2 cwt.), with a double line, at the expense of *fourpence* for powder and sabôt. Used as a separate and distinct conveyance from the life-boat launch, the Board of Trade could use this apparatus as part and parcel of their rocket apparatus; the Life-boat Institution could use it as part and parcel of their launching apparatus. In many cases where a wreck was within four or five hundred yards of the shore, I believe communication could be made by means of the cone and double line; and, certainly, if a double line was run out that distance, it would be a very great assistance for the life-boat to make a to-and-fro passage.

The CHAIRMAN: Is the total weight, hawser included, likely to be within the power of the draught of two horses?

Mr. ROGERS: Yes; it would not require two horses. An engineer went into this question with me, and we calculated that the weight would be something like a ton and a-quarter. It could be a framework of iron. The wheel would be five feet six inches in diameter, which would give light draught. For a hard road the wheel, from its construction, would only have a three-inch bearing; if it sunk into soft ground it would have a nine-inch bearing (pointing to the model cart). Another thing: in taking a cart like this down the coast, it is not a question of draught; there are always hundreds of men ready and willing to give assistance.

The CHAIRMAN: In summing up this most interesting discussion, I have to call the attention of the Institution to the fact that of all subjects which come before us, the majority are such as relate to the destruction of life. Therefore, we owe double attention, if we are worthy the name of British seamen and British soldiers, to those comparatively few inventions which come before us having for their object the saving of life, under circumstances in which either seaman or soldier may often find himself, and in which the greatest grief an officer can undergo, is to feel his utter helplessness in saving those who look to him for aid. I think, therefore, the

warmest thanks of this Institution are due to Mr. Rogers for bringing forward what seems to me to be a new and practical mode of effecting a hitherto very difficult object. It promises to give us a very great improvement over all that has hitherto been done, and I hope we may see it fairly and thoroughly tested; and not only tested, but adopted so soon as it is proved a success. I am persuaded that the money to be expended in either the testing or the establishment of such means of saving life and property, in case of shipwreck on our shores, would in a very short time not only be repaid, but its expenditure would command the applause of the public for those who had so wisely employed their money. I beg to tender to Mr. Rogers the warmest thanks of the Institution for the able paper he has given us.

Mr. ROGERS: I beg to thank you, gentlemen, for the kind manner in which you have listened to my paper, and for the assistance you have thus given me.

Evening Meeting.

Monday, January 31st, 1870.

VICE-ADMIRAL SIR WILLIAM H. HALL, K.C.B., in the Chair.

NAMES of MEMBERS who joined the Institution between the 17th and 31st January, 1870.

LIFE.

Nixon, John, Major, New Zealand Militia. 9*l*.
Fraser, Hon. A. K. D., Lieut. Gren. Guards. 9*l*.

ANNUAL.

White, Henry D., C.B., Major Gen. 1*l*.
Morice, James A., Lieut. Royal Marine Light Inf. 1*l*.
Webster, Joseph, Lieut.-Col. ret. (f.-p.) 78th Highlanders. 1*l*.
Castle, M. McCoy F., Lieut. R.N. 1*l*.
Cunynghame, Henry H., Lieut. R.E. 1*l*.
Vickerman, W. J., Captain 36th Middx. Rifle Volunteers. 1*l*.
Maquay, W. H. P., Lieut. R.A. 1*l*.
Russell, C. J., Lieut. R.E. 1*l*.
Kingsford, T. H., Lieut. 1st Roy. Surrey Militia. 1*l*.
Nelson, Thomas, Major E. and N. York Militia Artillery.
Holcombe, W. A., Ens. 6th Regt.
Ball, Edward A., Ens. 6th Regt.
Grundy, Frederick L., Lieut. 6th Regt.

THE FISH-TAIL RUDDER FOR ALL CLASSES OF VESSELS.

By J. McGRIGOR CROFT, Esq., M.D., M.R.C.P.

MR. PRESIDENT AND GENTLEMEN: I desire to bring before you this evening a new form of rudder, which I have designated the "fish-tail" rudder, as its action is taken from that of the fish's tail.

Before entering into the matter, I wish to exhibit these three models which have been lent me by the Institution, in order to show the forms of various classes of rudders. You have first of all, Mr. Lumley's "jointed rudder;" you have, secondly, the "balanced rudder;" and thirdly, you have the "fish-tail" rudder for the same class and form of vessel, so that you will be able to observe with these, their different proportions and forms. This model, viz., that of the "fish-tail" rudder, must stand on its own merits. I make no comments with regard to any other principles. The "fish-tail" rudder is the result of observations made by myself when looking at some gold fish in a glass aquarium for other purposes, which I hope ultimately to bring before this Institution. Observing a gold fish propelling itself quietly, I noticed that, when it was inclined to turn round, the upper flange of its tail was curved over in a diagonal form, which helped to bring it round; the lower flange of the tail apparently hanging listless. I was so much struck with this, that I watched very frequently for the action to occur again; and I noticed that the fish invariably, after a slight propulsion of the body, when it was inclined to turn for its own purposes, always flanged the upper part of the tail, as I have stated. I subsequently communicated the fact to several scientific gentlemen, and I am happy to tell you that, although a period

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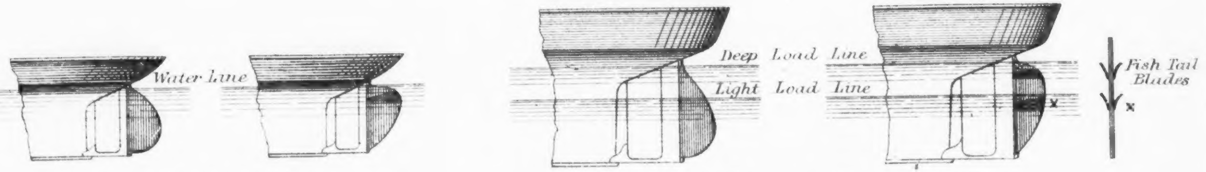
Dr CROFT'S PATENT FISH-TAIL RUDDER.

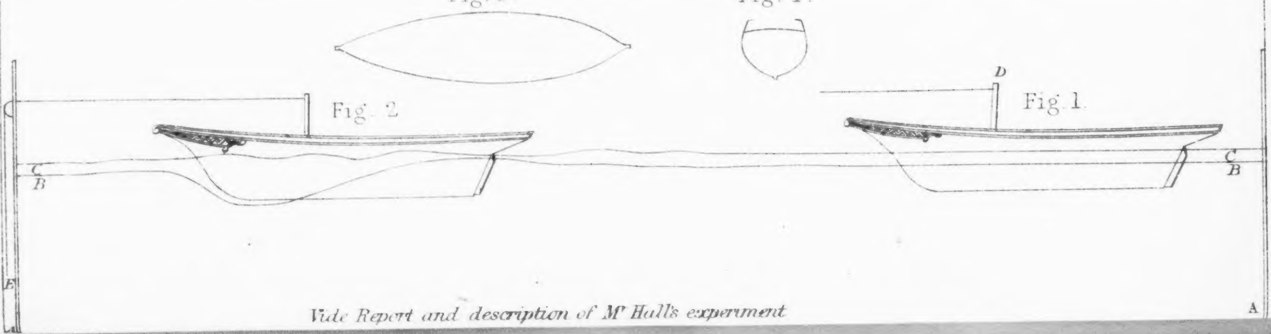
Various Designs.



For Gunboat or for Boat of Shallow draft.
Ordinary Rudder. Fish-Tail Rudder

For Ship of War or for Merchant Vessel
Ordinary Rudder Fish-Tail Rudder.

NOTE. For Merchant or other Vessels with variable immersion from light and heavy loading the lower blades below light load line marked with cross on sketch are added.



Vide Report and description of Mr Hall's experiment

J. Jobbins

of two years has passed since then, I have had my statement confirmed as being true, so far as the gold fish observed in the aquarium is concerned.

Arguing from the supposition that other fish are likely to do the same thing from the same principle, I reduced the idea to that form of rudder which I thought would possibly be the best means of steering a ship. I should say that the rudder of a ship is for the main purpose of steering; but the object to be obtained from a rudder is not only steering, but that in so doing you shall not materially obstruct the passage of the ship through the water, even when she is turning, as it is a very serious matter. At the same time, the rudder should be made of such a form that it should be strongest where strength is most required. The neck of the rudder, made according to the old principles, when a heavy sea strikes it below, gets twisted. In order to get over that difficulty, the rudder has passed into various forms, and the heel has been cut away. Having a small paddle-wheel steamer propelled by clock-work I applied the ordinary form of rudder, of the proper proportion, and my own, for experiment. I simply reversed the ordinary form of rudder most in use in the present day. I found that a rudder largest just beneath the water line, which is my form, at the same angles, viz., at 15°, 20°, and 25°, (the best angle for a rudder when turning,) gave almost exactly the same turning power as the ordinary rudder. Then, reflecting upon the fish turning the upper flange of its tail (of course, nature leads it to do so naturally, but it does not follow that we can do as it does exactly, without an immense amount of complication), I produced, as you will see upon these models, an imitation of the twisting of the fish's tail at a certain horizontal curve, by putting a flange of metal on either side of the rudder beneath the surface of the water. (See Plate III.) The moment I tried the experiment I discovered that I got an enormous steering property, without the immense drag upon the heel of the rudder. I carried out this experiment very carefully, and also successfully; and I believe there are gentlemen here—particularly naval gentlemen, who observed for themselves, and who have no doubt as to the value of the principle—who can verify the fact.

I may say with reference to a fish which I have brought here for you to see, a mackerel, that when the mackerel swims, the tension of the muscles of the back render the fish almost horizontal in the water, inclining the tail upwards. That fish has also what we term ventral and pectoral fins. The question might be raised with reference to the gold fish, did it depend entirely upon the twist of its tail for the purpose of turning, or were these adjuncts the principal parts for turning the fish? The fins of fish have several actions; and those fins, when the gold fish suddenly starts in the water, act as propellers. Also, if the fish, when at rest, is suddenly inclined to turn round, it will manipulate with either the starboard or the port fin, and begin to turn; but I think that the tail, with the power the fish possesses of curving its upper part, forms the chief turning power.

Here are models of different forms of rudder. This is the old-fashioned barge rudder; here is the improved rudder, in which the

heel has been cut off. I have questioned many naval men as to the object of rounding off the heel of the rudder, and have been informed that it was rounded off so that in case the vessel bumped on the sand, the rudder might not be unshipped. Nevertheless, it was found, that when the heel was cut off, there was decidedly better steerage; but how it was gained they could not tell me. The reason was unknown, and as I consider my ideas are right, I shall be glad to submit to you the discussion of the whole subject. Going into the question of the best form to be taken for the steerage of a ship, you will find that I use the broader part of my rudder above, and these little flanges are for the purpose of shutting down the up-rush of water.

I cannot here do better than read a document which was placed in my hands a few months back upon an entirely different idea, viz., the means of discovering the best form of vessel for speed. It is a report by the late Mr. Hall, of Aberdeen, the builder of the celebrated clipper ships. The document was laid before me by a gentleman who was rather sceptical as to my theory of a down draught taking place under the bow of a vessel, and an up-rush of water beneath the stern and along the upper part of a rudder, and that *below this current* there was dense water, which is of no use but to act as a drag upon the ship.

With your permission I will just read a description of what Mr. Hall, of Aberdeen, in 1846, undertook to experiment upon. The experiment was undertaken for the purpose of determining the best form of vessel, as he supposed, for the clipper ships of the day. But he never at the time thought of the principle which I have subsequently developed from the fish, and which I have taken the most advantage of. This is a description, first of all, of a vessel at rest, and then under propulsion in the water. I would ask you to look at these diagrams while I read the paper (see plate III., figs. 1 and 2):—

"The accompanying drawing attached, represents an experiment "made in order to observe the motion created in water by a vessel "passing through it, and to ascertain the best form of bow for dividing "the water. AA is a canal 10 feet long by 16 inches deep and 12 "inches broad, the sides composed of glass, so as to enable the motion "of the fluids to be observed when disturbed by a vessel passing "through them. The canal was filled with clear water to the line BB, "say 10 inches deep. Spirits of turpentine (of a red transparent "colour) were then poured on the water to the line C, being 1¼ inches "deep. Various models were provided, made from the plans of vessels "which had been built; these were tried separately, and at various "depths. The results from the various methods all showed the "decided tendency of the upper fluid to pass downwards; but the "model shown in the accompanying drawing gave the clearest demon- "stration thereof. Fig. 1 shows the vessel in a state of rest. A line "was attached to it at D, and carried over the end of the canal. An "observer, by looking through the glass sides, could see the motion "made in the fluids when the vessel was set in motion by a small "weight being made fast to the line E. The result was as shown in "Fig. 2, the velocity at the time being 2 feet per second, or 2½ miles "an hour. It is, therefore, seen that the red fluid, although lighter

"than water, runs down when pressed on by a body in motion; and to "to the best of the observer's judgment, at least one-third of the red "fluid displaced by the vessel escaped by passing downwards along "the bottom and bilges; and the cause of its rising upwards before "it reaches the quarters must be attributed to its difference in "density. The thinness of the red fluid at the rudder is deserving "of notice, as the remainder of it passed off from the quarters of the "ship, forming what is called the wake or track, which must be "considered as the water rushing up at the quarters from the "bottom. The confinement of the water by the sides of the canal "was not the cause which produced this effect, as the fluid did not "rise in the least degree on the sides of the glass, which it would "have done had that been the cause, and there was a clear space "of 4 inches at each side between the vessel and the side, the size "of the model being 24 inches by 4. Neither can it be owing to "any peculiarity in the horizontal or transverse shape of the ship, "as may be seen, Fig. 3 being the lead line, and Fig. 4 the midship "section. Although the above is at variance with the hypothesis "formed by most writers on the subject, yet, judging from the above "fact, it must appear evident that the perpendicular longitudinal lines "of the fore-body ought to be as acute as the horizontal lines; thereby "giving as fair course for the water downwards as for dividing it "horizontally. This is most fully attained by making the whole "bow forward, which enables the longitudinal lines to be made "more acute, and the shape approaches nearer to the appearance of "a fast swimming fish than any form that has hitherto been tried; "and as all vessels are designed for moving on the surface of the "water, the great fore rake above is designed to keep up the sharp "bower bow, which it does most effectually, as in vessels built on this "plan the fore parts have always been found to be driest, however "acute the horizontal lines may have been. Concerning the after "body, although the above experiment does not make the case out so "clearly, in consequence of the less density of the red fluid, yet from "the fact of the water having to rush up the after-run, it follows that "the after perpendicular lines (usually termed buttock lines) ought to "be formed as acute as the horizontal. This is accomplished best by "raking the whole of the after body along with the stern-post. It is not "proposed to shorten the keel to obtain these uncommon rakes; but "make the vessel longer above, which has also a very important effect "in reducing the tonnage as taken by the new Registry Act, without "curtailing the capacity. The improvement of the marine of this "country being of the utmost importance, we consider it the duty of "all connected therewith to make known to the profession everything "which may tend to elucidate truth, and we therefore submit the "accompanying drawing to their inspection."

It was with reference to the form of the vessel that Mr. Hall was operating, and that the bow and the rudder were cut away. I take advantage of this document to show you the water, with a film of coloured turpentine, and as it was with the vessel at rest and in motion. The red liquid is, as you see, completely sucked under, and ejected in

a narrow powerful stream astern at the upper part of the rudder. It was on that account that I adopted my form of rudder, having originally noticed the fish's tail-movement.

I cannot now do better than proceed to read reports of competitive trials, as an ounce of fact is worth a pound of theory. Whatever we may produce in theory must be reduced to practice before it can carry any weight with it. I will, therefore, read reports of competitive trials with ships of large tonnage, steamers, screws, life-boats, and even with racing boats upon the Cambridge river.

The first report is from Captain James Simpson, R.N., late of Her Majesty's Royal steam yacht "Victoria and Albert."

From Captain James Simpson, R.N., *late of Her Majesty's Royal Steam Yacht, "Victoria and Albert."*

"35, Chichester Villas, Kilburn, W.,
"October 24th, 1868.

"Dr. Croft.

"Dear Sir,—I have tried the Broadstairs lugger "Tartar," 15 tons, fitted with " your patent fish-tail rudder. We stayed her three times with the common rudder, " in a moderate breeze and smooth sea; 1st, 24 seconds; 2nd, 23 seconds; 3rd, 20 " seconds. The rudder was shifted, and when sail was made again, I took the " tiller, and was struck with the power of your 'patent rudder.' She was then " stayed under similar circumstances, and the times were—1st, 16 seconds; 2nd, " 17 seconds; 3rd, 15 seconds. In my opinion your fish-tail rudder is a very great " improvement on the ordinary one, requiring *less strength* to put the helm up or " down, and answering her helm quicker. I have had considerable experience in " large ships, and in my opinion your rudder would be of the greatest service in " our long vessels. Wishing your invention every success,

"I am, dear Sir,
"Yours truly,
(Signed) "James Simpson,
"Captain, R.N."

A trial has been made over at Dunkirk by some French shipowners under the management of an English engineer associated with them. The following is the report in French:—

"Commission Impériale de Surveillance des Bateaux à Vapeur.

Rapport sur une expérience du gouvernail muni d'ailettes "Croft."

"Dunkerque, le 3 Novembre, 1868.

"'L'Orphéon,' bateau à vapeur, ayant ses deux extremités pareilles et munies " chacune d'un gouvernail semblable.

"Le tirant d'eau est le même à l'avant et à l'arrière. L'arbre des roues, à pales " fixes, est juste au milieu du navire qui a 36 mètres de longeur.

"Un des gouvernails est muni d'ailettes "Croft."

"Dans une sortie de navire, faite pour expérimenter la machine, on a essayé des " virements de bord comparatifs avec les deux gouvernails.

"On faisait le tour du bateau à feu "Le Mardyck," la machine, battant 28 tours " dans les deux experiences.

"En gouvernant avec le gouvernail simple, l'autre étant fixe et de l'avant, " l'évolution fut faite en 4 minutes.

"La seconde évolution, faite en ayant pour le gouverner gouvernail 'Croft' à " l'arrière, fut faite en 3 minutes 15 secondes, *toutes les circonstances étant les mêmes.*

"Il est à remarquer que ce navire était, avant les réparations et changements, peu
" gouvernant.

"(Signé) CH. ROUILLE,
"Membre de la Commission, Chef des Pilotes.
"(Signé) H. P. TERQUEM,
"Membre de la Commission, Professeur d'Hydrographie au
"port de Dunkerque.
"(Signé) T. PAUWELS,
"Membre de la Commission, Conducteur des Ponts et Chaussées.
"(Signé) DELBEKE,
"Capitaine au long Cours, Commandant "L'Orphéon,"
"pendant les expériences."

I would tell you that in this instance the rudders were cut well away down below. I object to the principle of my rudder being large below, because the principle I wish to develope is obstructed by the dense water which you see on either side down there. The experiment was carried out entirely without my knowledge, only the design was given by myself. It was an experimental trial, and where you find, as you do here, 45 seconds' difference, it is an important matter in the revolution of a vessel. I would proceed now to read the report of the trial of the rudder by those practical and able men on the coast of Kent, at Broadstairs, than whom finer seamen are not to be found in the world. They are men who are called upon at night and in winter, and they are not likely men to use a rudder which they could not well handle :—

"Broadstairs, Isle of Thanet,
"22nd September, 1868.

"I hereby state that Dr. Croft's fish-tail rudder has been frequently tested by me " on my lugger 'Tartar,' as to its power and quickness in steering, *versus* the " ordinary rudder of the vessel. I can state truly that the new rudder is easier to " handle, and the lugger stays, wears, and steers quicker under canvas than with " the ordinary one. The stronger the breeze and heavier the sea has proved the " fish-tail rudder to be a great success, and as my vessel is generally out in all " weathers, looking for ships in distress, around the Goodwin Sands, I have perma- " nently adopted the fish-tail rudder, on account of the extreme handiness of the " vessel with it. The lugger stayed in 15 seconds with the new rudder, 23 seconds " with the old one, tiller at same angle.

"S. HOLBOURN, JUN.,
"Owner of the lugger 'Tartar.'"

This is a confirmatory fact with reference to what Captain Simpson said; pretty nearly the same proportion of time. Here is another report from Captain Baker of the Board of Trade, and Thames Conservancy Board :—

"'Oriental Club,' Hanover Square,
"London, 22nd September, 1868.

"Dr. Croft,
"8, Leadenhall Street, E.C.

"Dear Sir,—I have on two occasions tried the Broadstairs Luggers 'Tartar' " and 'William,' fitted with your patent fish-tail rudder. On the first occasion " the wind was moderate and light; on the second occasion there was a strong " breeze, with a great deal of sea on. In my opinion, on both these trials, your " rudder proved a more *serviceable* and a more *powerful* rudder than the old one. " Previous to these trials, I had heard that the blades on a boat fitted with them, " had caused the rudder to jump up and down when she pitched; but I found this

"not to be so, particularly in the second trial mentioned, although we had a good "deal of sea on, and the lugger pitched deeply at times, more especially in stays. "In my individual opinion, your fish-tail rudder would prove *more powerful*, and "quite as safe a rudder, if fitted on any-sized vessel, whether sailing only, or pro- "pelled by steam, and more especially would it (in my opinion) be found service- "able when running fast before a strong wind and high sea. I found that with your "rudder both these luggers stayed *quicker* than when the old rudder was shipped.

"I am, dear Sir,
"Yours truly,
"Rd. Baker."

I will call attention to this. The Ramsgate authorities were desirous of fitting my rudder-blades to the "Bradford" lifeboat, and I gave directions to Mr. Forrest of the proportions I formed which would suit any boat. These rudder-blades, as I supposed properly made, were sent down and tried, and when I went over to Ramsgate, I was informed the men of the boat did not like them; they tried them in heavy weather, and the grip was stated to be powerful, but the result was, that the rudder jumped up and down. I asked to see the blades; they were bent (not as I designed them) like the spread of an eagle's wings, of a proportion fit for a vessel of 3,000 tons. I had them removed at once for alteration. The proportion of my rudder-blade is very small. I was very sorry the rudder had been tried, because the ill news spread very rapidly, and it damaged my invention so far. Here is another report:—

"Broadstairs, Kent,
"August 4th, 1868.

"We hereby state that Dr. Croft's fish-tail rudder has been tried by us in competi- "tion with the ordinary rudder on our lugger, "William," under canvas, and from "the practical results we have proved the fish-tail rudder to be decidedly superior to "the old rudder, in staying, wearing, or direct steering, and with greater ease in "putting the helm up or down.

"One fact proved the fish-tail rudder to be superior was, the lugger would not "stay under her jib and mizen in a sea-way with the old rudder, but readily did so "with the new one. The width and area of surface of both rudders are alike, but "the principle of Dr. Croft's rudder is totally opposed to the best form of rudders "we are accustomed to use on our boats on this coast; but, nevertheless, we "have tested the fish-tail rudder in a heavy sea-way also, and now intend to adopt it "permanently for our lugger, in consequence of its great power and ease of "steerage.

(Signed) "Solomon Holbourn.
"Thomas Holbourn.
"James Castle.*
"James Holbourn.
"Owners and Boatmen."

So many have been the trials, that I will only pick out a few of the most important for you, as I do not wish to take up the time of the gallant Admiral who is to follow me this evening with his paper:—

"Hartlepool,
"April 1st, 1867.

"T. B. Winter, Esq., Engineer,
"28, Moorgate Street, London.

"Dear Sir,—I have much pleasure in giving my testimony to the inventor of the

"* Coxwain of the Broadstairs National Lifeboat."

"fish-tail blades, fitted upon the rudder of the ship 'Thornbey,' both for ease in "giving her the helm and answering it quicker, as well as taking the vibration off "the rudder.

"I was some time in the sister-built ship "Ludworth," (s.s.) and I am able "to testify to the great improvement in this ship in her steering.

"(Signed) ANDREW GRAHAM.

"Master 'Thornbey' (s.s.) London, 304 tons register."

"Thames Conservancy Engineer's Office,
"44, Trinity Square, Tower Hill, E.C.,
"February 17th, 1868.

"My dear Sir,—Your fish-tail rudder has been fitted to the 'Thames,' Conser-"vancy steam-boat, and having now been on trial for some time, *versus* the ordinary "rudder, I have no hesitation in saying that it has proved very successful. The "boat steers much better when going ahead, and in going astern the improvement "is very great.

"Yours very truly,
"(Signed) STEP. H. LEACH.

"J. McGrigor Croft, Esq., M.D."

The next report is from Captain Ward, R.N., of the Royal National Life Boat Institution:—

"Royal National Lifeboat Institution,
"14, John Street, Adelphi,
"London, May 22nd, 1867.

"Dear Sir,—I am happy to inform you that our Honorary Secretary at Deal "reports favourably of your fish-tail blades attached to the rudder of their lifeboat. "They had been tried in a strong breeze and heavy sea, and the coxwain reported "them to be a decided improvement. We will have them fitted to seven or eight "more large boats.

"I am, dear Sir,
"Faithfully yours,
"(Signed) J. H. Ward, R.N.,
"Inspector of the Royal National Lifeboat Society.

"Dr. J. McGrigor Croft,
"8, Abbey Road, St. John's Wood."

"East Bute Dock, Cardiff,
"June 30th, 1867.

"Dr. Croft,—I can highly recommend your patent fans or blades, as they have "greatly improved the steering of my vessel.

"If this testimonial is of any service, you can make use of my name.

"Yours respectfully,
"(Signed) JOHN FISK,
"Master s.s. 'Caroline,' London."

Now, that is a particular vessel, built upon a design of Mr. Scott Russell's. With the rudder anterior or in front of the screw, steamers on this plan are ascertained to be the biggest brutes to steer in a river or open sea way. Mr. Henley, the owner of this very vessel, came to me and said, "if you can physic the rudder of my vessel, I shall "certainly support your plan strongly." I did not like the style of

rudder because it was all below the casing of the screw shaft. I told him that a certain amount of steerage might be improved, but as to the completion of the power of my principle, I would not guarantee that. At all events, we put a large pair of blades upon this rudder, which was rather of a long form horizontally, instead of being deep. The result was that this vessel, which was perfectly unhandy and dangerous on Mr. Scott Russell's plan, now steers well.

The CHAIRMAN: What is her tonnage?

Dr. CROFT: About 200 tons. She carried a large portion of the wire cable. When the "Great Eastern" went out to lay the first Atlantic cable, the "Caroline" took round a large portion of the ground cable laid at Valentia. I now come to a sailing ship, the "Roman Empire." In all these instances I would never apply my blades to any rudders, except they approached my form very considerably; and I never guarantee the total results of this principle unless the greater part of the rudder is just under the water line. Mr. Duncan's ships have a remarkable quantity of rudder cut off, which he has considered right. He wished to apply my rudder-blades, and three of his vessels of large tonnage were fitted with them, and this is the result:—

"East India Docks,
"February 12th, 1868.

"Sir,—Your fish-tail blades having been applied to the rudder of my ship "previous to her last voyage to Calcutta and back, and having commanded her "before she was fitted, I have the honour to inform you, that the fish-tail blades have "decidedly improved the steering of my ship under all circumstances of weather, "either in a gale or moderate. I have found the blades equally successful and of "great advantage in the Calcutta river.

"(Signed) JAMES MATHER, Master.

"To Dr. Croft,
"8, Leadenhall Street, London."

Now, questions may be asked, as to a vessel lifting on a sea, what rudder will you have to hold the vessel? That question has been very often put to me by naval gentlemen. It is right on my part to say, and I have proved the fact, positively proved it upon lifeboats, upon shallow boats running upon the top of a surf, that a vessel when lifting on a roll of the sea, until she comes completely to her bearing by her own speed has no power of steering; that a rudder made large down below, for the very purpose of holding that vessel, is really the very reason why many boats are held in the sea and caught athwart by the waves; while with my rudder the vessel will immediately answer her helm. I have put it to practical test among the seamen on the coast, and they are delighted with it when they find it to be so.

I will now read one fact with regard to lifeboats, where my principle was put to a very severe test:—

"Arklow, Ireland,
"June 5th, 1868.

"As Assistant Honorary Secretary to the Arklow branch of the Royal National "Lifeboat Institution, I accompanied the boat, in order to test the properties of "Dr. Croft's fish-tails to our boat's rudder. I selected the most stormy day it was "possible, in the month of January, with the wind off the sea, with a very heavy

"broken water. Our coxwain had no trouble in steering her. Having got well out "to sea, we had sail made, and found (contrary to former occasions) that the boat "not only stayed, but wore round readily in a very small circle. As a last trial, we "determined running through our narrow pier heads (which formerly we dare not "do without using the drogue), and found that she was perfectly under command "of the rudder, which no doubt is attributable to what I shall here designate an "invaluable improvement on steering apparatus, 'Dr. Croft's fish-tails.'

"STOPFORD W. HALPIN, M.D.,

"Assistant Hon. Sec., and Admiralty Agent."

To proceed from that to one other report. The celebrated "Cambria," with which you are aware a challenge has been made to race the American yacht, has made a trial with my rudder complete upon her; and I will read you the result:—

"Schooner yacht 'Cambria,' 180 tons,

"Gravesend, June 3rd, 1869.

"To James Ashbury, Esq.,

"Owner of 'Cambria,'

"Sir,—Having tried the patent fish-tail rudder (Dr. Croft's invention) on this "vessel, in a run from Cowes to Gravesend, I am of decided opinion that the vessel "answers her helm much quicker on all points, and particularly in stays.

"Yours obediently,

"(Signed) F. SPENCER,

"Master of 'Cambria.'"

I will take one more report to show that my principle is applicable to all classes of vessels. Within the last few days, a trial has been made with my rudder on the racing boats. Mr. Searle, the eminent boat-builder, who is well known to all those who are interested in river aquatics, had a consultation with me. I proposed to have a rudder made upon my own design, *versus* the rudder that is in use for these little boats. I gave it to him, and he sent it down to Cambridge, to a gentleman of very great experience and authority there with all Cambridge men. Those who know the Cam will understand that it is a very tortuous river, and boats racing among themselves have to turn at right angles at one or two corners. The power of my rudder was to be tested on these racing boats. Messrs. Searle wrote to me to say they sent the rudder down, without the slightest comment, but to try it against the ordinary rudder. I guaranteed certain results to them privately, and the rudder was sent down, and fairly tried by the same crew *versus* the ordinary rudder. I have the pleasure of reading the report which was handed to me by Mr. Searle:—

"Chesterton, Cambridge,

"January 17th, 1870.

"Dear Sirs,—I have tried Dr. Croft's fish-tail rudder, the result being most "satisfactory. Being determined that the rudder should have a fair trial, we (the "crew) rowed from Cambridge to Baitsbite, $3\frac{1}{2}$ miles from the former, and back to the "boathouse. The river, as you know, winds considerably, and has several very bold "corners, 'Ditton,' 'Grassy,' and 'First Post,' being nearly at right angles. The "boat steered admirably at the corners, requiring very little rudder; in fact, I am "speaking truthfully when I say that the rudder was not placed at half so great an "angle as that to which the ordinary rudder was subjected when we used it at the "same corners upon the return journey, and yet the boat came round more easily

"and quickly than when using the ordinary rudder. It seemed to me that the great "advantage resulting from the use of the 'fish-tail' is, that at the corner you do not "have to put on half the rudder, as I before stated; and therefore escape the great "resistance offered by the ordinary rudder, which, when placed at so great an angle, "impedes the speed of the boat, and is not helped by the rush of water coming up "almost level with the top of the yoke. The boat, of course, held her way in a "straight reach equally well.

"I may just say that Mr. Winter also tried the rudder, and endorses all that I "have said about it. The gentlemen will be up in about ten days, and I will then "get some of them to try the rudder.

"Yours truly,
"(Signed) EDWD. THOMAS.

"To Messrs. Searle and Sons,
"Stangate, Lambeth."

Now, that is a report without the slightest clue being given as to the principle or the power of the rudder. The writer is considered by Mr. Seale to be a trustworthy, honest, and practical man. It is merely a confirmation of all the reports which I have laid before you. I would simply wind up by saying that the question of the proportion of these little blades is an important matter. They are exceedingly trifling, but they are exceedingly powerful. The value of this principle, if it has a value, is that it is invaluable to all classes of ships, particularly in manœuvring ships of war. I need not say that a vessel which can turn quickly, and not have her speed checked, and is a powerful ram, would have her enemy at her disposal. I trust this rudder may be brought before the Government in a substantial form. I am inclined to think that there is a disposition towards it, but I await events. I invite discussion; and if any questions are asked, I will, as far as I humbly can, answer them.

Admiral RYDER: Will you tell us how far beneath the surface of the water those blades are fixed?

Admiral HALSTED: For myself, I beg to state that I am very much obliged to Dr. Croft for what he has brought before us, and in this I think I may at least carry with me the rest of the meeting. There are very few things in which there are more differences of opinion, and very few things more important than the question of the best means for steering screw ships. The difficulty is increased infinitely according to the increased size, power, and cost of our ships. Therefore, whoever may bring before us in these days, improvements in regard to steering, we are deeply indebted to him. This plan seems to be of great simplicity, as far as we can see; it possesses great facility of application, as far as the proofs which have been put before us go; great efficiency of effect; therefore, we are bound to recognise Dr. Croft's efforts for our help, and for our—I will not quite say our salvation—but certainly towards our safety. Of course, it has a general advantage as applied in the way in which he proposes to apply to it; but I am afraid one must say, necessarily, that there is a further experience still before him beyond that to which he has already attained; and that, of course, he is no doubt prepared for, especially as he refers to the necessity of getting the authorities to take it up. But as far as it goes, there seems nothing whatever in the principle itself, or in the effects which it has been recognised to produce, which should not bid us encourage and support him by our best wishes for his success. We very gratefully thank Dr. Croft for the efforts he is making in so valuable and important a direction.

The CHAIRMAN: I quite agree in all that Admiral Halsted has stated. I should not like this meeting to break up without returning our best thanks to Dr. Croft for his perseverance, and for the improvement which he has brought forward this

evening. I would strongly recommend him to persevere, and endeavour to get some shipowners and others connected, particularly, with large ships, to try the plan, and not to forget to try the Admiralty. Because the Admiralty are a little inclined now, as we shall hear from Admiral Inglefield, to take up new inventions introduced by naval officers and other persons. It is quite a new era in their affairs. As one of the directors of the Peninsular and Oriental Company, I assure you I shall give Dr. Croft every assistance I can in order to get one of our ships fitted with his rudder, and give it a trial in a ship going from here to Shanghae and back again.

Captain Jasper Selwyn, R.N.: I wish to go a little more into the subject than has yet been done by Admiral Halsted, who I hoped would have done it, as I think it is an improvement of very great value. Dr. Croft has sufficiently demonstrated that, so as to encourage the gallant Admiral in the chair, to make the kind intimation he has thrown out. It is not every one who will tell you what he is going to do. But if the improvement is of value in itself, I think it is also of extreme value to an inventor that he should have a fair and open discussion of his system. And that can scarcely be done by simply returning the thanks of the meeting. I have had the pleasure of knowing Dr. Croft for some time, and of knowing his invention for some time. I have turned a great deal of attention to it. It seems to me to have its practical value from the fact that water escaping near the stern of any shaped vessel is caught and thrown back again on to that part of the rudder near the surface. But this will vary very much with the different shapes of vessel on which the rudder is employed. Where you get a very badly-shaped vessel, like some of our old East Indiamen, with what is called a square tuck, and very short run, you will find dead water near the stern, in which Dr. Croft's apparatus would not have fair play. We have to recollect that the experiments of naval architects have been directed to the subject of the skin current, that is, the current carried along with the vessel; and that those experiments which Dr. Croft has shown us of Mr. Hall's, bear principally upon the fact that he provided a thin film of material of lighter specific gravity, which was also carried along with the skin of the vessel, and which showed in that particular instance how the water near the skin of the vessel was affected, but did not show anything else. It would be wrong to rely upon that as any illustration of what took place in a very fine run of a very long vessel, where it is quite possible that the water, being able to come together more rapidly, owing to the better form of the ship, might have more influence on a rudder lower down, and require less deflection. We shall recollect that wherever the negative current or dead water round the stern occurs, we have also a remarkable action of the screw, due to the same cause, called negative slip. But that deflection caused by those blades would operate differently in those vessels with the square tuck from what it would in vessels with a long fine run. Then, secondly, I think there is something in what Dr. Croft has stated—indeed, a very great deal more than we have hitherto considered—as to the action of a ship when she is plungeing and kicking her rudder out of water. There is no doubt the forward plunge of the bows arrests the forward way of the ship, and the rudder becomes useless; and the instant she raises her bow again she recovers her forward way, and then the rudder comes into action again. I do think, therefore, that the long-heeled rudder, though it is valuable in a barge and in a badly-shaped vessel, is an error in our present forms, and may give place to the form of rudder which Dr. Croft has advocated, until we get a little further in advance, and that I hope to see him bring out.

Dr. Croft: I shall be very happy to answer Admiral Ryder. The blades I put on, as an average rule, about a foot beneath the water line in deep ships, and in very shallow ships about six inches. That, in trials has been found the most successful. The nearer you can control the up-rush of water, so that it does not come to the top, the better. With regard to the screw ships, there is a large amount of consideration. As Captain Selwyn has remarked, I am quite alive to the principle that the water which actually comes under the run of the vessel is rotated by the screw; and on this consideration have I been compelled to put the blades more on the horizontal line; then, with a certain slope upwards, as I can shut down the water of the screw blade. In a sailing-vessel there is nothing to impede the rush. With reference to some ships that I have fitted that have steered very badly—some old

Indiamen—I would tell Captain Selwyn, for his satisfaction, where they have been very full vessels aft, the steering was wild, that the very fact of putting these blades upon them has made them very handy indeed. I have only to say I thank the gallant officers for their kind remarks, and that my mind is open to any discussion on the matter. As Captain Selwyn says, there may be more purposes got out of this simple application of the laws of nature, which remain still to be developed. I am not above learning, and hope to obtain many valuable hints still on the subject. I would also thank Admiral Halsted for his very kind and honest remarks. I know that he is not one to flatter an invention, but is determined to see its value. I take his remarks as a golden opinion, which I accept from the gallant Admiral, and I shall leave this place satisfied that I have laid truth before you.

The CHAIRMAN: Before Dr. Croft goes away, we return our thanks to him for his valuable communication.

Dr. CROFT: I beg to thank you. My profession is that of medicine. It is supposed we should keep to the orthodox; but I do not see why we should not make use of our minds to promote the interests of other professions.

"MEANS OF SCREW-SHIP STEERAGE, AND A DESCRIPTION OF THE HYDROSTATIC STEERING-GEAR FITTED ON BOARD H.M. SHIP 'ACHILLES,' WITH THE RESULTS OF EXPERIMENTS AT SEA; ALSO PLAN OF APPARATUS FITTED ON BOARD THE TURKISH IRON-CLAD 'FETHI BULEND.'"

By Rear-Admiral E. A. INGLEFIELD, C.B., F.R.S.

IT is notable that for several years, "offensive" as well as "defensive" preparations for maritime war have been carried on by European nations, with an energy which, as regarded the one or the other, was deserving of a more marked success; for example:—In this country the manufacturers who strove to perfect a weapon which should possess sufficient strength to burn a charge of powder capable of projecting an enormous missile with high velocity and marvellous powers of penetration, have succeeded so well, that their labours might have been described as eminently successful, had there been none to devise a more perfect protection for the sides of our war-vessels than existed in the days of wooden line-of-battle ships. But so it is, that these inventors of guns and projectiles, have been met, at every step in their advance towards an anticipated success, by naval architects and engineers, who rivalled their zeal, and who have produced with equally successful results, armour-casing and other devices in the construction of war vessels, which defy the efforts of the gunner, and make next-to-nought of the penetrating powers of the heaviest ordnance which can be carried on board our ships. Thus, in reference to our great guns for ship use, we literally find, as regards the work required from them in penetrating a ship's side, that they are somewhat inferior to those obsolete weapons which were thought so perfect, and which proved so effective in the days of Nelson.

In any future maritime war, great speed, heavy armaments, and ponderous armour will be the qualifications of the combatants on both sides,

for foreign nations have not been slow in following our example, and at times in taking the initiative.

Among naval Officers there are divided opinions; eager advocates for this as for that principle of attack and defence, can it be doubted that when the hour for actual conflict has arrived, that, with the modern appliances of steam, huge cannon, charged with heavily explosive missiles, devilish devices in the shape of torpedoes, and beyond and above all, the wholesale destruction which the ram prow will carry before it—I say, can it be doubted but that when once the belligerent squadrons are ranged in opposing lines of battle, the combat will be brief and bloody? That each, then, in his turn and place, should aid by example, precept, or device, in making our war ships as perfect as possible, is unquestionably the duty of every naval Officer.

It is not my purpose in the following pages to discuss either of those qualifications which constitute the warlike capabilities of our vessels, with reference to armaments or armour. I propose to speak of what relates to that element in the capabilities of a fighting ship, without which armaments are comparatively valueless. I allude to the locomotive properties of our vessels of war, and especially that element which gives to a ship all the value of its locomotive powers—I mean the method and self-contained ability to direct and vary the course—when proceeding at the highest rate of speed, with the greatest rapidity, certainty, safety, and precision.

A naval writer makes the following apt remarks upon this subject. He says,—

"In all fighting ships there is one especially weak point which, if "successfully assailed, at once places the vessel *hors de combat*, and "leaves her entirely at the mercy of the enemy. This point is the "steering apparatus, the destruction of which leaves the ship a useless "log upon the water, unable even to run away, unless Providence had "previously placed her head in such a position as might admit of such a "manœuvre being possible. No matter what may be the perfection of "every other part of the ship, no matter though her battery be "impregnable and armed with irresistible weapons, all can be rendered "absolutely useless by one well directed blow at the steering apparatus, "which in all vessels, whether old-fashioned or new, is more or less "exposed. Not only is the apparatus exposed, but the men at the "wheel, put them where you will, are liable to be swept away, and "the ship at a critical moment left helpless, either before an evil-dis- "posed enemy, or in the vortex of a storm."

This is the point at which I am aiming in first speaking of modern improvements. It will hardly be credited that at this moment there are only three of our powerful iron-clads which, not having been fitted with balanced rudders—a comparatively modern introduction of Mr. Reed's—possess the means of obtaining the full effect of their rudder-power according to the designs of their builders, and when I say this of our own ships, I am not far from the facts, in asserting that in this respect we are not inferior to foreign nations. I do not impugn the authorities for this apparent negligence in the equipment of our war ships; I believe the Admiralty and the Chief Constructor of the Navy,

are thoroughly alive to this great want, and it is only because the rapid strides of our shipbuilders and engine manufacturers in the production of long fast ships, have found no one to keep pace with them in the development of some plan or system, whereby may be ensured a safe, certain, and rapid control of the helm, when high velocity is the rule of action.

It is thus that in the noblest and most perfect specimens of naval architecture ever produced, and which are worthy of our importance amongst maritime nations, we find, with three exceptions, the same antiquated appliances for steering as were used on board the grandly ornamented craft in the days of good Queen Bess.

Those who take an interest in these matters must have had the facts to which I allude brought vividly before their minds, if they perused the graphic letters in the *Times* from its correspondent on board the Channel Fleet, during its recent summer cruize. It was stated by him that on one occasion the "Minotaur," which carried the Admiralty Flag, was for a short time quite ungovernable in a heavy seaway, through the inability of the united efforts of *fifty* men to steer the ship—so impotent was the power of her steering gear! I think under these circumstances, that any Officer who may have the opportunity and leisure, with a certain amount of experience, to collect and embody data on this important subject, will not be toiling in unprofitable ground; and thus I take upon myself, after some years' experience, and no little amount of thought and study, to improve my own observations by a careful comparison with that of other workers in the same field—men who are well qualified to speak, not only from their official positions and scientific attainments, but from the result, in some cases, of well devised experiments.

The able papers read before the Institution of Naval Architects, on the subject of "screw-ship steerage," by Vice-Admiral Halsted, Mr. Barnaby, Assistant-Constructor of the Navy, as well as Mr. Barnes, of the same department, have afforded me much valuable information, and I shall quote from them largely, as doubtless their opinions will have more weight than any words of mine, and I am desirous of establishing my case, as regards the existence of a great *want*, before offering, as the excuse for my theme, the *remedy*.

I have said that as far as my unofficial knowledge went, there were only three of our first class iron clads with any mechanical arrangement for steering, other than the old fashioned, long tiller, with its many fathoms of hide rope led along vulnerable spaces to a cumbrous wheel placed on the quarter-deck, supplemented, it is true, by what is called the fighting-wheel in some more secluded part of the ship, but still dependent for its utility on the same tiller, rope gear, and a gun's crew of men.

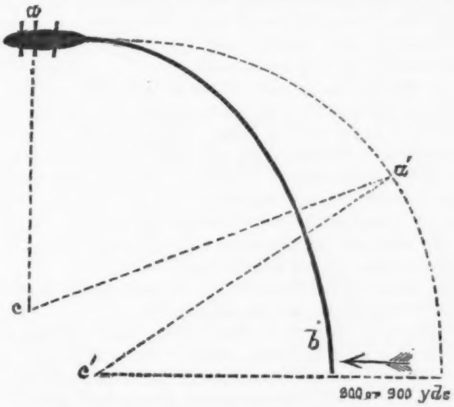
The three ships in favour of which I make an exception, are the "Northumberland," "Monarch," and the "Achilles," the two former having steam steering-gear, and the last, a particular adaptation of hydrostatic-hydraulic-apparatus, concerning which I propose to speak more fully later on.

The steam steering-gear fitted on board the "Northumberland" and

"Monarch" is an adaptation of steam-power to the ordinary barrel around which the tiller-ropes are coiled; this barrel is placed between decks, and has a most ingenious automatic arrangement, so as to meet the demands of ordinary steerage.

Mr. Gray, the patentee and inventor, has well illustrated the capability of steam to perform this service, and I believe that nothing can be more perfect than the action of his engine; *but*, for fighting purposes, there still exists the long tiller and tiller-ropes, and there must be steam in the boilers, *and to spare*. On board the "Northumberland," I was informed, that while the small steering-wheel on the upper deck could be worked with facility by one man, the rapidity of action as regarded the rope-barrel was such as to require the constant attendance of a seaman to keep the turns from riding. A stoker was also frequently in waiting upon the engine.

Before I go further into the general question of the "steerage of screw ships," I will for a moment draw attention to the accompanying diagram, taken from a well digested paper, written by a distinguished mechanic, Mr. Froude, on the subject of the hydrostatic steering-apparatus on



board the "Achilles." He illustrates the case of the "Cadmus," which got ashore last year at Salcombe, not far from Torquay. "She *all but* "cleared the rock; a little greater speed in getting the helm over "would have enabled her to clear it altogether." He says "In fact "if the ship with her helm at the best angle can form a circle with "radius *c a*, she will *at once* begin to move in that circle, if the rudder "is *at once* brought to that angle, and she will follow the course *a b* "in the diagram, whereas if time elapses in getting the helm over, she "will follow some such imperfect curve as *a a′*, till the proper angle is "gained, and only then will she begin to move in the circle. A vessel "going 12 knots goes 1,200 feet per minute, and if it takes 63 seconds 'instead of 30 seconds to get the helm over, she will have gone fully

" 800 or 900 feet more towards the point which it is desired to " avoid."

The foregoing pre-supposes that the power *exists* for obtaining a full rudder-angle, though *time* is required to accomplish it; what then if the greatest rudder-angle obtainable, be only 15° instead of the 35° or 40° for which the helm has been "bearded?" This I shall presently show is the normal state of our war-ships' steering abilities.

To follow up the case of the vessel *a*, exemplified by the diagram, it is clear that had she been supplied with an apparatus which could have commanded a rapid movement of her rudder to its extreme angle, and so diverted her course with greater rapidity from the impending danger, a catastrophe would have been avoided; in other words the vessel would have turned in a smaller circle, and thus covering less ground, would have avoided the dangerous locality.

It would appear, then, from the foregoing, that if it were possible to put the helm over to its extreme angle in two seconds, the risks of collision with another vessel, or stranding upon a rock or shoal, would be greatly lessened; but it must be borne in mind that the power necessary to produce such a result must be so enormous, when applied with such rapidity, that it would almost amount to a blow, and that it might, and probably would, end in wringing the rudder head, or fracturing the tiller, or some of its appurtenances.

Perhaps, in the mind of a sailor there would exist another disadvantage. If the steering-apparatus is constructed to put the helm over to a maximum angle in so short a space of time as two seconds, it would be impossible to give the oft required and most necessary quick *small* helm, which is the perfection of steerage, unless a provision were made which could throw the rapid-movement-action in and out of gear at short notice; a complication very undesirable where huge forces are concerned. To meet all the demands on the helm, I think 30 seconds a fair allowance of time to get a helm hard down.

And now to review for a moment the present position of the steering capabilities of some of our largest ships of war.

I find Mr. Barnaby stating in the paper which he read before the Institution of Naval Architects, that "the 'Warrior' and 'Black " Prince,' in turning a circle, traversed a space so great, that in passing " through 90° they would have to travel nearly half a mile." He adds, " that in these ships the ordinary means of steering were as perfect as " they can be made." Further on he says, " that in nearly all our " screw-ships the men at the wheel cannot hold the rudder at the ex- " treme angle for which it is bearded, but have to exert all their force, " when the vessel is at full speed, in order to hold the helm at 15° or " 16°." What this force is, and what the number of men required to exert it, is well illustrated by three occasions, one very recently in the case of the " Minotaur," to which I have previously alluded, another, when experiments were being made with the " Black Prince," when, to quote from Mr. Barnaby once more, " she was turned completely round in " 8′ 33″, the rudder being over to 28°, but in order to hold it there it " required 10 men at the wheel, and 30 at the relieving tackles, no less " than 40 men being employed at this operation. This, says he, is of

" course an extreme case, but it serves to show that *an invention which* " *promises to reduce the number of men required to one or two, has great* " *claims to consideration.*"

Thirdly, my own experience, when in command of the " Prince Consort," an iron clad of 4,000 tons, on an occasion of experimental circle-turning, I placed eight men at the wheel and 25 men at relieving tackles in my cabin, and at full speed they were unable, with their utmost efforts, to obtain a full rudder-angle. " Rudder-surface," and " rudder-angle " are the qualifications which constitute the whole value of " rudder-action," and no one will dispute that these must form very important considerations in the ship-builder's plans.

I am not in a position to state what is the rule or standard by which the " rudder-surface " for any particular vessel is calculated, but I have little doubt that the length and draft of a ship, taken together, constituting what may be termed the longitudinal wetted or immersed area, form one of the principal guides in the determination of rudder-area; and this seems natural enough, for a vessel of great length must necessarily demand a greater leverage on one extreme to cause her to move out of the direct line of course in which she may be progressing, than a ship of half her length. Whether or not this be the rule in determining rudder-area, it affords a very fair standard of comparison, and I propose to notice the proportions of such areas in a few cases. I find that at mean load draft—

	Rudder area.			Longitudinal immersed area.
Himalaya has	1	foot	to	60 feet
Achilles	1	,,	,,	58 ,,
Warrior	1	,,	,,	51·5
Black Prince	1	,,	,,	51·5
Defence	1	,,	,,	48
Arethusa (screw)	1	,,	,,	47
Royal Oak	1	,,	,,	44·4
Arethusa (sailing)	1	,,	,,	41·3
Ariel	1	,,	,,	37·3
Hood	1	,,	,,	35
Terror	1	,,	,,	23·8

Admiral Halsted, in his elaborate paper on "screw-ship-steerage," referring to the above says, " A mean of the proportions shown by the " steaming *Ariel*, with full rudder-surface and full rudder-angle, the " *sailing Arethusa*, and the both sailing and steaming *Hood* has been " taken as forming, on the basis of experience, a just standard of what " proportions between rudder-area and immersed longitudinal-area, all " naval, if not mercantile, screw ships should possess, in order to " realise full 'screw-ship-steerage.' This mean gives 1 foot of rudder-" area to every 38 feet of immersed longitudinal-area; and tested by " this standard the 'Warrior' and 'Black Prince' show a deficiency " in rudder surface of 62 square feet or 34 per cent. The 'Defence,' " and vessels of her class, show a deficiency of 35 square feet or 25 per " cent. The 'Royal Oak,' and her class a deficiency of 26 square feet

" or 17 per cent., and the 'Achilles' a deficiency of 86 square feet, or " 53 per cent. Thus, if the standard itself, and the means of obtaining " it, be judged fair and practical, and the calculations correct, then no " charge for defective powers of turning in our large armour-plated " ships can be substantiated, nor ought to be made, against either the " ships themselves or the true application of the true screw in the only " true place for it, viz., the dead wood in front of the rudder, while " these grave primary defects still remain unremedied."

The foregoing will show there exists a great disproportion of surface-area in the rudder of vessels enumerated; whether other conditions have determined this disproportion I know not, but I think we shall be able to detect a reason in the paper of Mr. Barnes, from which I shall have occasion to quote in treating of rudder-angles. From my own observation I can say, that having cruised both in the Channel and Mediterranean squadrons with several of the vessels named, I have often had cause to observe how various and limited were their powers of turning at all speeds; and here I must speak of another cause which probably contributed largely to this short-coming, viz., a want of full rudder-angle, whether due to a lack of room for proper tiller-action, or equally, want of ability to obtain a full rudder-angle through the feebleness of steerage power.

Now these are qualifications which so seriously affect the steering qualities of a vessel, that they must not be lightly regarded.

In vessels (such as the "Warrior") having screw-wells, to obtain a proper sweep for her tiller, a yoke has been fitted somewhat similar to a gig's yoke in principle, though the necessary gearing was varied. In ships without screw-wells, a full length straight tiller is employed, and the ordinary threefold reeving of tiller-ropes. Under these conditions it would appear that no difficulty could exist in giving the tiller any amount of rudder-angle, *provided* power sufficient is always at command. Now what do we find stated by a high authority on this subject, after a series of experiments made in the "Terror," at Devonport.

Rear-Admiral Key says that the officer in command of the Reserve Fleet at Portsmouth, had remarked the same want of command over the rudders of our screw-ships at full speed which had been observed by himself and Admiral Halsted. The experience at both ports being that in ships of above 400 N.H.P. only one had commanded a rudder-angle of 20° from which they had sometimes fallen to 11° only.

Admiral Key says in another place: " I can distinctly state that I " found a decided advantage of both time and space in every additional " degree of angle up to 40°, the limit to which the 'Terror's' tiller " could work. Between that and 45° I found advantage as regards " space, but a very little as regards time. The old limit of 32° was " made for sailing-ships, as of course it was inadvisable to stop their " way, but with screw-ships the more you stop their way the better."

We now arrive at the point which I think explains the varying proportions in the rudder-areas, still, however, referring to rudder-angles, and remembering that it is admitted the power did not exist for obtaining the full rudder-angle for which it had been bearded.

Mr. Barnes in his scientific review of the "Relation between the "powers applied to turn the ship," tells us, that "assuming the powers "applied to the steering-wheel to be equal in both cases, a ship will turn "more quickly with a small rudder than with a large one, because the "angle at which the small rudder can be put over, is greater than the "angle at which the rudder of greater area can be put over.

"In our large iron cased ships, also in the Mersey class, and in high "powered ships of the merchant navy, the inclination of the rudder "obtained with the usual power at the wheel when the ship is under "full steam, is about 15°. If under these circumstances rudders had "been fitted so that with the same power applied at the wheel, the "inclination would have been 30° then (without going through his "algebraic equations) it may be briefly put—

Small rudder. Large rudder.

$$b \;=\; B\,\frac{\sin.\ 15^\circ}{\sin.\ 30^\circ}\ \text{(from equation (1))} = \tfrac{1}{2}\,B\ \text{very nearly.}$$

"Again the effect of the rudder to turn the ship in the two cases "will be as sin. 30° to sin. 60° or as ·5 to ·866, or as 1 to $1\frac{3}{4}$.

"It is clear then that if the breadth of the rudders of these ships be "reduced one half, and an inclination of upwards of 30° be obtainable, "the same power applied at the steering-wheel will produce with the "narrow rudder nearly double the effect produced with the wide "rudder, and consequently the ship will describe a circle of about one "half the diameter of that described with the large rudder."

And here, I take it, lies the real difficulty with regard to the standard of the proportions for rudder surface, viz., that *the size of the rudder has to be kept within dimensions that can be controlled by steerage power*, but once let us acquire that necessary force, equal to any demand of rudder-area, and the rudder-surfaces of our ships may be restored to their full dimensions, and a greatly increased duty will be the result.

Mr. Barnaby asks in following up the subject of rudder-areas, and the forces we can apply—

"Is the rudder large enough to absorb, and to absorb economically "all the power we can put upon it? There are in fact certain considera- "tions which show, that as a general rule, our rudders are too large." Mr. Barnes concludes, "that rudders which cannot be worked at large "angles are not economical, and should be reduced in area until they "can be worked." "If," says Mr. Barnaby, "a problem of maxima "and minima be constructed expressive only of the first two conditions "here laid down, it appears that the rudder would be most effective in "turning the ship if it were over at an angle of $54\frac{3}{4}$°, but if the fourth "or economical condition be also brought in as one of the conditions "of the problem, so as to discover with what angle and breadth of "rudder *a given power* on the wheel may operate most effectively on "the ship, the angle comes out 45°, and of course the breadth of "rudder such that the power will just maintain that angle.

"Although this undoubtedly shows that rudders which can only be

" worked at 15° or 16° are too large, yet I am afraid that the neces-
" sities of a ship, which must be sometimes under sail and sometimes
" under steam, will limit improvement in the ordinary rudder in this
" respect, for a rudder which could be held hard over when under steam
" would certainly be too small when under sail."

Doubtless, with these considerations fully before his mind, and alive to the great importance of obtaining a full rudder-angle with a large rudder-area, Mr. Reed, the Chief Constructor of the Navy, not finding an available power to obtain this full rudder-angle with sufficient rudder-surface, has wisely adopted, as the only apparent alternative, the balanced-rudder in its simple form, as fitted to the "Bellerophon," "Monarch," "Inconstant," "Invincible," "Audacious," "Vanguard," "Iron Duke," and "Hotspur," in its more complex form of jointed-balanced-rudder in the "Hercules" and "Sultan." In all these vessels yet fully tried, the practical as well as mechanical effect is all that can be desired. It is, however, very necessary that the proportions before and abaft the line of axis should be nicely determined; it is also requisite that the officer commanding a ship fitted with a balanced-rudder should thoroughly understand the peculiar properties of this form of rudder, or he may be liable to pronounce a hasty judgment which at a later day he must recall.

There is no evidence, as far as I am yet informed, to prove that the balanced-rudder may not be as safely hung, and as securely placed, as the ordinary stern-post rudder.

An accident which occurred to the balanced-rudder of the "Inconstant," and of which so much has been made, in no way affected the principle. In that ship there were special reasons for making the body of the rudder for the most part of brass; this was the first time that brass had been employed for the purpose, and there was consequently a want of data to go upon in determining the sizes and proportions required for the various parts, which in this case happened to be done in a dockyard. In addition, it appeared after the accident, that the casting was somewhat defective at the part where fracture took place, although no defect could previously be discovered by the closest inspection.

These were the causes of the accident, and they were obviously independent of the form of the rudder, that is, whether balanced or simple, while the experience then gained is likely to prevent the occurrence of similar accidents in other ships with brass rudders.

It should be explained that the jointed-rudders of the "Hercules" and "Sultan" are brought into an altered condition from a balanced rudder to that of an ordinary rudder when under sail; they then lose all their mechanical advantages of easy motion by the ordinary steering wheel, and we must under such circumstances be content with a loss of rudder-angle.

It may be useful here to give some idea of the times of turning ships with ordinary and with balanced-rudders, in order fully to appreciate the mechanical advantages of the new system; this may be obtained from the following figures, shewing the results of official trials at full speeds of the iron-clads now in the Channel Squadron.

As the differences between the lengths and proportions of the ships doubtless had a considerable effect on their performances, the lengths and breadths are also given.

Ships.	Rudders.	Length.	Breadth.	Time of turning a complete circle.	Diameter of circle.
		ft. in.	ft. in.	min. sec.	Yards.
Minotaur..........	Ordinary rudders.	400 0	59 $4\frac{3}{4}$	7 38	939
Northumberland* ..		do.	do.	7 25	842
Agincourt		do.	do.	8 20	977
Warrior		380 0	58 4	9 10	1050
Hercules	Balanced rudders.	325 0	59 0	4 0	562
Monarch		330 0	57 6	4 40	609

The foregoing table shows that the mechanical difficulty of getting the helm over for want of a sufficient power to apply to the tiller, is well met by the application of the balancing principle to the rudder, while a far larger surface is exposed to the action of the cylinder of water set in motion by the ship's engines. The nearer, therefore, we approach in our rudder-surfaces to the diameter of that cylinder of water, the nearer we undoubtedly arrive at the maximum turning power, which a given set of engines, in a given ship, at a given speed, at a maximum angle of the helm, can produce.

In estimating the value of steerage experiments, it should be borne in mind that a screw-ship will always turn quicker in one direction than in the other; this is due to the action of the column of water driven by the screw having a greater effect on one side of the rudder than it has on the other.

Practical experiments show that the ship turns quicker to the side on which the blade of the screw in revolving *descends*.

If a rudder be left free when the ship is going at speed, it will be found that the helm will incline some degrees from the line of keel. It is clear then that a screw-ship in steering a straight course, must carry a certain amount of either port or starboard helm, according as the screw is either right or left-handed, and in turning circles, this angle should be taken as though the helm were amidships.

There are those who may be content to leave matters, as they were satisfied that what has stood us in such good need for so many years, answering all the purposes of ordinary steerage under all ordinary circumstances, will suffice for the future; but to those I would say, the every-day circumstances under which our ships put to sea, and navigate in all parts of the world, are no longer *ordinary*, but *extraordinary* circumstances; and if this be true for the every-day life of a ship, how much more true will it be, when all the extraordinary self-contained

* The "Northumberland's" steam-steering-gear was used in this trial. With only ordinary steering appliances (similar to those of the "Agincourt" and "Minotaur") at work, she took 8 min. 9 sec. to go round a circle of 1,013 yards diameter.

powers of our war vessels are strained to their utmost extent in the day of battle; this seems to be the general opinion of naval Officers and naval architects generally. To quote from Admiral Halsted once more, he says,—

"Whenever a fleet of, say twenty such ships as the "Warrior," in "close order, shall be suddenly signalised to manœuvre, or change their "formations for battle in face of an enemy, and gun after gun from the "Admiral enforces rapidity of evolution, there can be no stopping of "engines to put helms over, unless with the certainty of confusion, if "not collision. But on the other hand we may rest assured that that "Fleet will be found best prepared for the emergencies of that day, "which shall be best provided with the means of using the greatest "rudder-power which the highest engine-work in each ship can give; "and such a provision when realised for the Navy, may be equally as "valuable to the commercial screw-ship also, in the dark nights or "foggy day, as means of increased safety from collision, with ship or "shore, iceberg or reef, or water-logged derelict."

Mr. Scott Russell, in discussing the paper on "Screw-Ship-Steerage," says,—

"So long as any ship in the Navy does not possess the power "of immediately—on the order being given—putting the rudder, which "shall be of an adequate size, hard over to 45°, and keeping it there "so long as the Officer in command of the ship desires it shall be kept "—I say as long as every ship in the Navy does not possess that "power—somehow or other, those who put these ships into the hands "of commanders are answerable. I am perfectly satisfied that, in "iron steam-ships at least, we can so construct the sterns of the ships "in regard to strength, we can so construct the tiller of the ship, and "we can so put convenient mechanism on the end of those tillers, as to "accomplish the end in view."

On another occasion the same gentleman, speaking on the same subject, says,—

"It is perfectly manifest, I am sure, to every practical man, that if "it be necessary for manœuvring to keep yourself out of danger, or to "run into mischief when you want to do so, if it be necessary to have "good steering power at a low velocity, it is infinitely more necessary "that with a ship that runs into mischief very fast, you should have "infinitely more control, and as more control can only be got by a "large rudder, controlled by large power, we are shut up very much "into the position of taking hydraulic power, or something else, and "compelling the big rudders of the big ship to go round."

Mr. Reed winds up his remarks on the paper from which I have so largely quoted by saying:—"I think the whole object of Admiral "Halsted's paper was to show, that you must have more steering-"power, and then you can do everything. That is what we all pretty "well agree with."

Having now established my case on the highest authorities, viz., that a great demand exists in the present day for a mechanical steering-power equal to the task of putting over to an angle of 45° the largest rudder that may be deemed proportionate, according to the immersed

longitudinal section of a given vessel, without any reference to the power employed, I come to the question of "means" to that "end;" and in justice to the subject and the labours of others working in the same field, I must first allude to the form of steam steering apparatus which exists on board two of the three ships I have previously named.

The steam-engine of this machine is in gearing with a barrel, round which the tiller ropes are coiled, the barrel is made to revolve rapidly at pleasure in one direction or another, and thus the helm is put over either way in a very short space of time; but as a long tiller and tiller ropes are employed, there still exists the danger of the tiller or tiller ropes being shot away in action, or the accidental carrying away of either, besides the continual drawback of stretching in the rope-gear. As I before remarked, in the "Northumberland," though one man can manage the small steering-wheel, it requires a seaman and a stoker to be more or less in attendance on the engine.

In the form of steering apparatus which I have fitted to the "Achilles"—the other of the three ships named,—I have endeavoured to overcome the objections to a long tiller and tiller ropes; to the necessity for more than one man to steer the ship; and, above all, to the dependence on steam to be able to use the apparatus at all.

My engine I have called an "hydrostatic-hydraulic-steering apparatus," and I use the word "hydrostatic" because I employ as a motor power the pressure which exists at the bottom of every floating body, more or less, according to the depth of water at which that body floats.

To utilize this power (which roughly is half a pound per square inch for every foot of draught), I admit through a Kingston-valve in the bottom of the ship, the external water, and convey it to an ordinary horizontal or upright cylinder, in the most convenient lowest space available in the bottom of the ship.

The water so admitted, is made to work a piston in the cylinder by an ordinary tappet-motion; the piston has a rod moving with every stroke of the piston in a double-action force-pump. Now the power obtained by this form of apparatus is as the number of square inches contained in the area of the piston multiplied by the number of pounds due to the height of the column of the external fluid, and thus increased, concentrates its maximum force at the delivery of the water from the force-pump. The machine fitted for the first experiment on board the "Achilles" was much too large for the work required, and gave an ultimate pressure (as shewn in the guage) equal to 600 lbs. on the square inch. The application of this extraordinary power to the purposes of steering the ship is simple enough, the water from the force-pump is conveyed through a directing-slide, which is the governor and directing power of the engine, to two hydraulic-cylinders placed on either side of a 4 feet tiller.

The rams working in these cylinders are connected with each other, and have a stout steel pin at their junction. It is by this steel pin that the tiller is connected with the rams; a moveable fork working in a clutch made to slide on the tiller, forming the method of connection, and

also giving the necessary freedom requisite for adapting the extreme positions of the tiller to suit the direct thwartship-movement of the rams.

The directing-slide is so arranged that the movement of a properly adapted piston working in a cylindrical chamber, through a space of five inches, will turn the high pressure water of the force-pump to either tiller-cylinder, or at its middle point place the two tiller-cylinders in free communication with each other, while at a point midway between the central positions and the extremes of the up or down strokes of the directing-slide, all the apertures are closed, and the water in the two cylinders locked in their chambers. The movement to the directing-slide is given by a minature wheel placed in the pilot-house on the bridge, with a duplicate on the lower deck placed under armour plate protection.

I have only given a general outline of the form of "steering apparatus" fitted on board the "Achilles," as I read in this theatre last year a paper describing it fully, with explanatory drawings, and I shall presently describe the form of improved apparatus being now fitted to the Turkish iron-clad corvette "Fethi Bulend," by Messrs. Kittoe and Brotherhood.

I must not, however, omit to give the results of the experiments made with the apparatus on board "Achilles."

Captain Luard in his official report of a full speed trial outside the breakwater at Plymouth says:—"The ship was steered with this apparatus on various courses without any difficulty, and with considerable accuracy, the lower wheel was also used in the same way, communication being kept up from the bridge by voice pipes.

"The chief points of advantage shown by this apparatus were these:—

"1st. Sufficient motive power always available.

"2nd. The steadiness with which the power applied overcomes the resistance of the rudder at the highest rate of speed, especially when the helm is nearly hard over.

"3rd. The security with which the rudder is held at any desired point.

"4th. The readiness with which the rudder is freed after being hard over, and thereby allowed to right itself rapidly when going at speed.

"5th. The ease with which the power is applied, one man being able to use it under any circumstances.

"6th. The facility with which the tiller is connected with, or disconnected from, the hydraulic rams."

At the time these experiments (which lasted four hours) were made, it had not occurred to me to test what effect upon the ordinary steering-wheel of the ship, would result from keeping the hydrostatic apparatus connected, but on a future occasion it was proved not to make any appreciable difference in the facility of action, whilst it demonstrated the unquestionable advantage of being able, when steering the ship in the ordinary way, to put the ordinary hydrostatic apparatus in action at an instant's notice.

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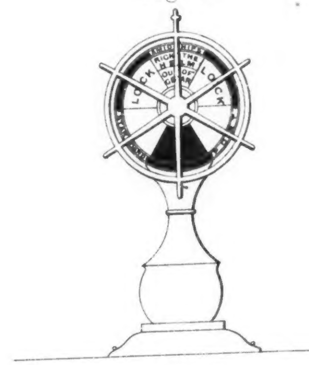
SECTION TO SCALE OF TURKISH CORVETTE OF 1600 TONS F

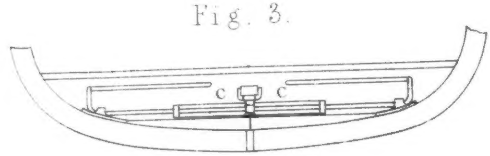
Rear Admira

Fig 5.



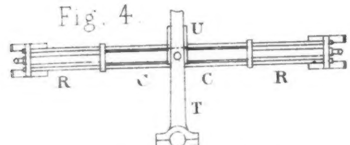
Enlarged View.

Fig. 3.



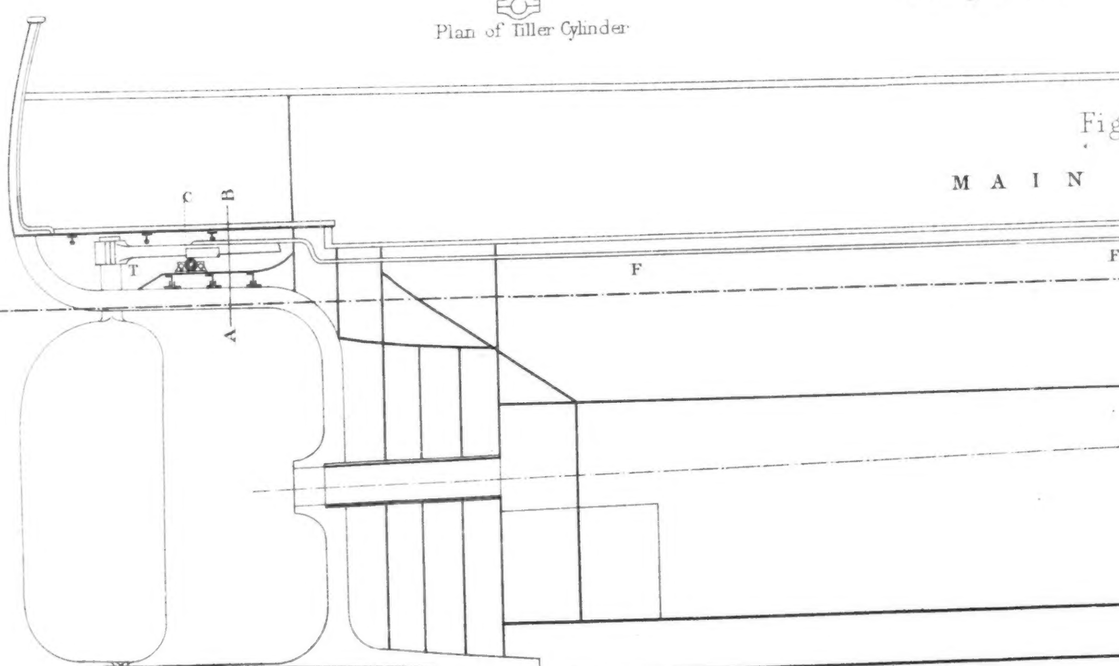
Section at A.B.

Fig. 4.



Plan of Tiller Cylinder.

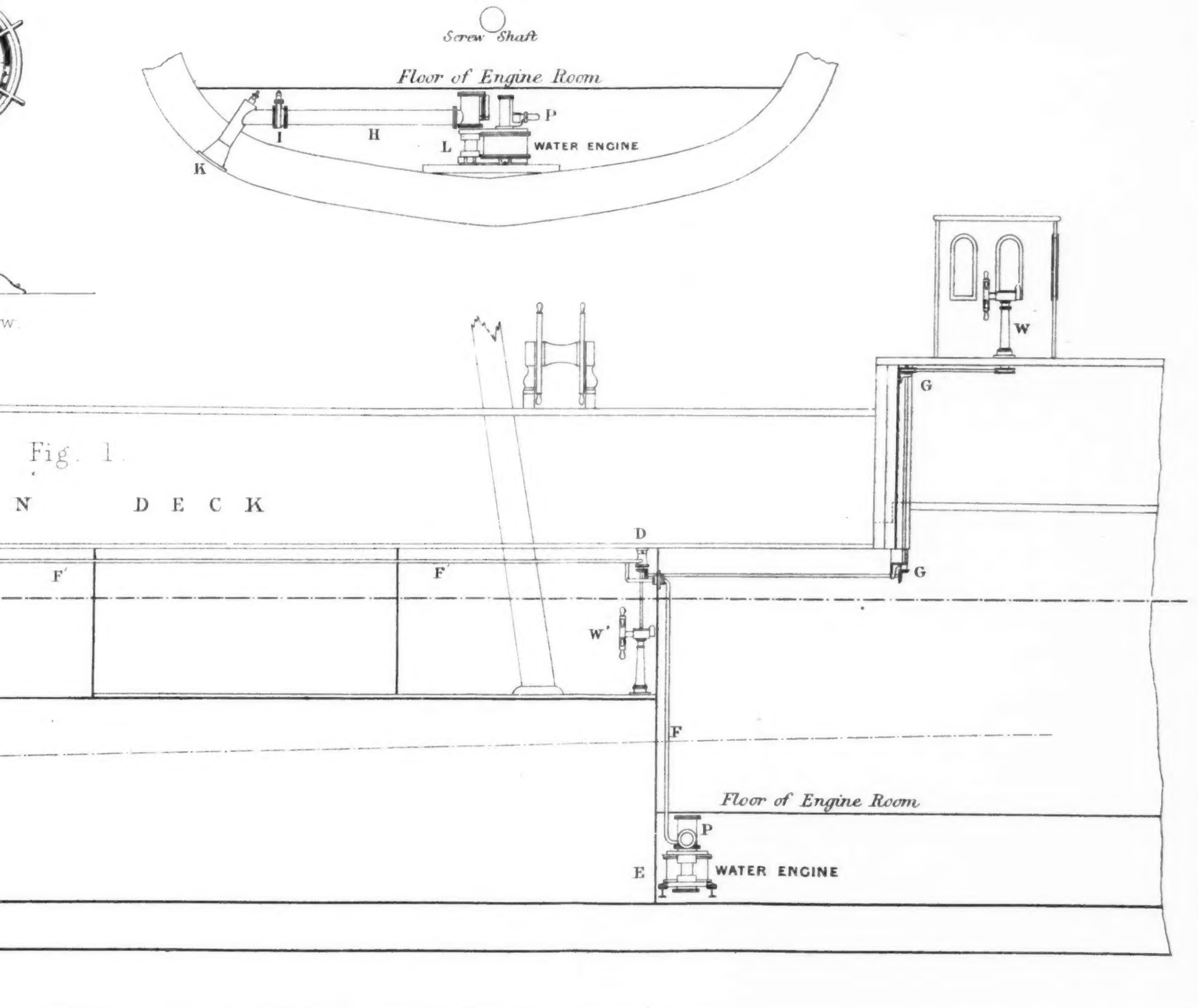
Fig



TONS FITTED WITH HYDROSTATIC STEERING APPARATUS INVENTED BY

Admiral Inglefield. C. B.

Fig. 2.



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The first trial of the apparatus showed that the power exerted was enormously in excess of the demand on the tiller, for, as I stated before, the gauge showed a pressure sometimes amounting to nearly 600 lbs. on the square inch, while the actual force necessary to put the helm hard down either way when the ship was going at full speed, did not exceed 150 lbs. on the square inch. There was a slowness of action in the movement of the water-engine reported by Captain Luard, but to remedy this was not a difficult task, as it required only to convert the large surplus *power* into *speed*. The slowness of the engine was due to two causes; the main from the Kingston valve had been made to perform such a tortuous route to avoid the magazine floor, that before the external column of water could reach the water-engine, it had to pass six quick bends, thus greatly reducing its force; the passages also into the water-engine had been made too small by some mistake in the working drawings.

At the final trial, after making some alterations to remedy these defects, a result was obtained which quite equalled my most sanguine expectations. A quotation from the reports, and a private letter from Captain Nolloth, will form the best conclusion to this description.

Officially, it was reported by the Captain "that in all cases the "helm went over to about 25° in 10 secs.; the maximum angle "obtained by the ordinary wheel being $24\frac{1}{2}°$ in 1 min. 17 secs.

"When the apparatus is connected, the ship can be steered by it, "or by the ordinary wheel, without any considerable extra strain "being thrown by one on the other. The chief engineer of the "'Achilles' (Mr. Lewis) informs me that the working of the machinery "of the apparatus was quite satisfactory."

Privately, Captain Nolloth writes to Admiral Halsted, in answer to his queries about the trial:—"I am sure you will be glad to learn that "on Saturday we returned to Portland after a *most satisfactory* trial of "Inglefield's apparatus. With it we can put the helm over to about "$33\frac{1}{2}°$." He adds:—"It is beautiful to think of one man—a boy even "—being able, with a little unpretentious wheel on the bridge, by a "turn of the wrist, to direct with ease the course of this huge "mass, and moreover to hold the rudder in a heavy sea-way under "a control unattainable by means of the ordinary tiller-ropes. Ingle-"field may well feel proud of his success."

From the Admiralty I have received an official letter, in which the Secretary states that:—"My Lords have great satisfaction in informing "you that the reports of the trial of your hydrostatic steering appa-"ratus, since the alterations, are satisfactory, and show that it will be "a valuable instrument in the 'Achilles.'"

Since the successful results of the experiments on board the "Achilles," Mr. Reed has directed the application of my hydrostatic-steering-gear to a Turkish iron-clad corvette building under his superintendence.

A description of this apparatus will be brief; it is smaller and simpler that that fitted to "Achilles."

In the plan (see Plate iv) which accompanies this paper is shown a section of the after part of the "Fethi Bulend," now fitting with my

steering apparatus. On the keel of the ship, under the engine-room floor, is placed the water engine, E, and which consists of a cylinder 24 inches in diameter, with a piston having a 1 foot stroke. The piston-rod is arranged as the plunger of a double action pump, P, and the movement of the piston and power is obtained by the pressure of the external column of water (equal to $\frac{1}{2}$ lb. per square inch for every foot of draft) being admitted through the bottom of the ship by a Kingston valve, K, shown in Fig. 2, a sluice valve, I, and main, H, communicating with the slide-box, L, fitted at the side of the power-cylinder water-engine.

By a simple arrangement, the movement of the power-cylinder is automatic, and continues to work so long as the directing-slide is open to either side of the tiller-cylinder. At each stroke, up or down, of the piston in the power-cylinder, water is forced into the pump, P, at a pressure multiplied by the difference between the areas of the bucket and piston. The surplus water from each stroke falls into the bilge, and is taken off by the bilge pumps. The forced water thus raised to a mean pressure of about 300 lbs. on the square inch, is conveyed by the pipe F to a directing-slide, D, Fig. 1, and from thence by two pipes, F', to either side of the after part of the ship, and there connected with two rams, R R, Fig. 4, working in a cylinder, C, which moves with the tiller, T, and adjusting itself to the angle by means of a sliding clutch, U, on the tiller.

The directing-slide D (Fig. 1) is the governing power of the engine, and to move this up and down through a distance of about 5 inches, or in a cock, through half a revolution, is all that is necessary to steer the ship.

The small steering-wheels W and W', one placed in the chart house on deck, and the other on the lower deck under armour-plate protection, are the appliances by which the directing-slide is moved, and it is only necessary to turn either wheel through three-fourths of its diameter to cause the helm to go from hard-a-starboard to hard a-port. Placing the midship-spoke at either extreme marked port and starboard (see Fig. 5), the helm will go over without any further action of the helmsman. When the midship-spoke is placed within the arcs marked black on the dial-plate, the helm will become locked, whatever its position, and when the midship-spoke is placed in the centre, the helm will right itself, without any movement of the water-engine, for the action of the water passing the rudder, rights it by its own force. Moreover, if the tiller-ropes are rove, when the hydrostatic-steering-wheel is in this position, the ordinary steering-wheel may be used, and no appreciable difference (as regards friction) can be discerned.

In conclusion, I may say that I believe all the conditions necessary to ensure a powerful, ever ready, rapid, economical, and easily managed steering apparatus are to be found in the form of engine I have proposed. Moreover, there can be little doubt that some such apparatus is much required; and that the demand is an urgent one, may be gathered from the expressions of an official authority, who has thought and written much on this subject, ending his remarks upon one occasion by saying,—" In whatever manner future naval engage-

"ments may be conducted, the result of those engagements must "largely depend upon the course which is now taken in providing "machinery for steering; but in view of contests between ships cased "with armour and equipped as rams, this question takes the very first "place."*

The CHAIRMAN: I am sure you will all join me in returning our sincere thanks to Admiral Inglefield for his very valuable paper. As an old sailor, I must say that I quite rejoice to think that this invention has been brought forward by one of my brother officers. I wish him every success, and I am sure you all do. It is not only we, but the whole country must be indebted to him for his very valuable invention. I am delighted to think that the Admiralty should have taken up the invention warmly, and that the results should have been so satisfactory.

Vice-Admiral HALSTED: Admiral Inglefield has been kind enough to mention my name in connection with this subject, to which I have devoted many years of effort in trying to bring it about. I most sincerely and warmly congratulate Admiral Inglefield, and I most sincerely and warmly congratulate ourselves upon the success of his invention. I would simply repeat that last sentence which he has read; the whole question is contained in it. I have paid great attention to his application of the apparatus in the "Achilles," not during its progress, but after its completion. I have been down to Portland twice for the express purpose of making myself master of it, so far as my ability would enable me to do so. Nothing could exceed the completeness, as far as I could apprehend it, of the whole application. But there is a point beyond that, and I think it is a very large point. I will not take long to express it, because of the shortness of the time at our disposal. I do believe that what Admiral Inglefield has done for us is really and truly the commencement of a very great and generally applicable discovery to many purposes far beyond those to which he has now applied it. It is the more remarkable,—it makes one almost smile to think about it,—that every ship we have, each and all, has been carrying about with her this self-contained or self-accompanying hydrostatic power, and we have never been aware that it could be adapted for our benefit in so many ways as I believe it is almost inevitable that it will be. I no more believe that that little, I was going to say, "contemptible thing," that is able to exercise that power of 300 lbs. per square inch for moving a mere tiller from starboard to port, will be limited to such work only, than I believe that the power of the ordinary steam-engine has yet found its limit of application. There is not a foot of that ship's bottom that will not give you, if tapped, the means of working an apparatus for doing something of the same sort as working the tiller. The power is always there; it is constant, it is costless; it is instantly applied. You have only to turn a cock, and there it is; you do not want to light a fire. I am perfectly convinced in my own mind, though I may be speaking hazardously, but it is my impression, so far as my examination of the "Achilles" goes, that this discovery of Admiral Inglefield's is capable of performing for us all sorts of valuable services. I have laid upon him this bond already, that he makes it turn our turrets, that he makes it work the guns in the turrets, makes it get up our anchors, and moor our ships. I do not see why it should not also pump ships. In coming to that point, there is a grave question with regard to it on which I venture to think more highly of his discovery than he does himself. He thinks that the apparatus cannot be made to pump out its own water. I think not only that it can, but I say again that the multiplicity of purposes to which he can apply those little apparatuses, will depend very largely on their being enabled to pump out their own water. Now, I will merely mention one idea which has crossed my own mind before coming here, and the minds of others also, with regard to the means which it possesses of doing this work for itself, and getting rid of its own waste water. He spoke of an

* P.S.—Since this paper was written, I have submitted plans to the Admiralty, showing that the same apparatus employed for steering can be readily adapted for turning the heaviest turrets.—E. A. I.

excess of power for the tiller work as having been produced in his first engine, in which he got 600 lbs. per square inch, and he says he now finds that 300 lbs. per square inch is ample power by which to work the tiller. Very good. I merely throw it out as a possible suggestion; why could not the other extra 300 lbs. per square inch be made, as it were, to protrude through the end of the piston, not the rod, but the case also, which he makes the means of getting up his hydraulic pressure, why should not such waste power be made to act externally through that or some yet more suitable means, and then you have got 300 lbs. per square inch available to set any other apparatus in motion, perhaps even in the same line. Admiral Inglefield has mentioned the able assistance he has procured from the engineers whom he has employed, the Messrs. Kittoe and Brotherhood. I perfectly agree with him in his commendation. After examining both the original engine in "Achilles," and knowing pretty well what improvements and simplifications the present engine is capable of, I am sure he could not express himself otherwise than highly grateful towards them. But I do think this—if I am right in my estimation—that what has already been done is a mere indication of what we may yet derive from that apparatus, and that the ablest and most experienced of our mechanical engineers are not a bit too good to be put into possession of the principles of this apparatus, and to be appealed to, so far as it is competent to do so, to aid us in developing what further services can be procured out of this practical discovery, as I regard it, which Admiral Inglefield has brought before us.

Captain Jasper Selwyn, R.N.: I am going to ask your permission to raise a point which I am afraid Admiral Halsted has forgotten. There is a certain process which goes on after you have let water into a ship, which requires power to get rid of it. He will kindly remember, that if he multiplies his engines, he must multiply the amount of water let into the ship, and that it is perfectly vain to attempt to get perpetual motion in any way. I am sure when he thinks of it twice, he will see that it cannot be done. I should be sorry that engineers should go away with the idea that naval men think that they can lift themselves in a basket. As regards the invention of Admiral Inglefield, I join most heartily in the congratulations which come to him from all sides, on the extreme ingenuity of his adaptation of the broad principle of hydrostatics which he has developed. I do so the more warmly because I had the pleasure many years ago of being his messmate; and we all know how warmly messmates always feel towards each other. With regard to the power as applied to the rudder, it is a beautiful expression of force applied to that particular purpose. But I submit that that force ought not to be required to be so applied, that it is an error to require it, and that it is as unnecessary to develope that force, which Admiral Inglefield now does, in the rudder in opposition to the water, as it is to the fish, who never does any such thing. When the fish, as Dr. Croft has shown us, wishes to turn himself, he does so by a very slight curve introduced into a flat surface. I must say that my views are entirely opposed both to the ordinary flat rudder and to the balanced rudder: more to the balanced rudder even than to the flat rudder, because as I see in the table before me, showing different lengths of ship and different rates of turning, the increased time which must be given to the increased length of the ship in the different ships themselves. I see the balanced rudder is doing much better, but we have not quite brought out how much is due to the changed shape of the ship, and what is due to the changed shape of the rudder. Until we do that, we cannot be able to define exactly what is the value of the balanced rudder. Next, I say the balanced rudder becomes a mistake the instant you put it over, not 32° but even 30°; the instant you do so, you introduce a force which tends to break the rudder in half in the centre. The quicker the ship is going, the more the water thrown off by the screw, the more you are trying to break your rudder in two. It is held at both ends, and you are applying the force in the centre which tends to break it. I dislike the balanced rudder, if we can do without it; and I think people will join me in saying, generally, that of all the disgraceful, ugly objects that were ever stuck on to the stern of a ship, and on an ugly stern, too, there never was a more disgraceful exhibition than that balanced rudder. It certainly does not follow nature in any sort of way; I do not think there is a fish in existence that would not be ashamed of it. Still, taking the machinery of the hy-

draulic press or pump, such as Admiral Inglefield has developed there with the assistance of Messrs. Kitto and Brotherhood, I think he has done the most we could possibly expect in so short a time to develope the utmost simplicity and the best results. I have no more to say than to congratulate him most warmly upon that development, and to hope that he may go forward; and not only give us a better application of power to the rudder, but a better rudder to apply the power to.

Captain J. C. Hoseason, R.N.: I wish to make one or two observations on Admiral Inglefield's paper. It must be evident to all present that he has clearly demonstrated that if the long, fast, ships are so slow in turning, it is simply due to a deficiency of rudder-area, together with a lack of mechanical power sufficient to force the helm over to the required angle. Therefore, all that we have been doomed to read in the public journals, with respect to the economy and efficiency of short ships, has been, as I always contemplated it would be, proved to be erroneous. In truth the marked gain in time whilst performing the complete circle, as shown by the "Bellerophon" over the "Warrior" and "Achilles," is mainly traceable to the increased size of the rudder-area of the former ship, combined with the facility of rapidly putting the helm down to a far greater angle.

This is what might have been safely predicted, from a careful comparison of the times taken in making the complete circle, by the "Warrior," "Achilles," "Pallas," and "Bellerophon." The "Warrior" and "Achilles" are both 380 feet long, or 80 feet longer than the "Bellerophon; but the difference between the draught of water aft and the draught of water forward, is no less than *five* feet in the case of the "Pallas" and "Bellerophon," whilst the two former long ships draw only *one* foot more water aft than forward—in plain truth, the little "Bellerophon," of 4,246 tons burthen, draws exactly the same water aft, viz., 26 feet 5 inches, as the "Warrior," of 6,039 tons; consequently, the "Bellerophon" has not only a far greater area of rudder in proportion to her size, but having also a balanced rudder, the helm can be moved over to a far greater angle and also with much greater rapidity—points of infinite value where the ship is moving at a very high velocity.

The official returns of the performances of the "Pallas" and "Bellerophon," in my possession, will still further serve to illustrate this point, and tends clearly to uphold the correctness of Admiral Inglefield's reasoning, and forcibly demonstrate the value of his invention. The "Pallas" is only 225 feet long; "Bellerophon" 300 feet. The "Bellerophon," consequently, is 75 feet longer than the "Pallas," or nearly as much longer than the "Pallas" as the "Warrior" is longer than the "Bellerophon," yet we find that the short "Pallas," that has not a balanced rudder, takes 4 minutes 12 seconds to make the complete circle, whilst the long "Bellerophon" performs the same in 3 minutes 59 seconds. This simple statement of facts makes powerfully in favour of Admiral Inglefield's exposition of the case.

Nobody will deny that, *cæteris paribus*, the shorter ship will turn in less time and space than the longer vessel; but the marked difference in the time required by the "Warrior" to complete the circle, viz., 9 minutes 8 seconds, and the "Achilles," 7 minutes 17 seconds, must be traceable to other causes than to their greater length. This also is conclusively demonstrated by comparing the times occupied by the "Warrior" and "Achilles," two vessels of equal length, in making the complete circle, for we perceive that the "Achilles" takes nearly two minutes less time than the "Warrior," a marked difference when the size and immersion of the ships, both forward and aft, are nearly identical.

Many have lately listened to a very interesting paper, read at the Institution of Civil Engineers by Mr. Grantham, who has satisfactorily demonstrated the advantages to be derived from increasing the length of all ocean steamers in proportion to their beam, and we cannot fail to congratulate Admiral Inglefield in having so ingeniously and scientifically invented the means of effectually steering these long vessels, without having occasion to resort to the cumbrous machinery as at present employed in combination with the balanced rudder.

Admiral Inglefield: I think there is hardly anything for me to reply to, in the shape of a question. I can only say, in reference to Admiral Halsted's suggestions, as to other work that may be done by my apparatus, that I have sent in plans to the Admiralty, and they are before the Controller at this moment; a process by

which (exactly the same sized engine as that shown in the plan) we shall be able to steer the ship and turn both turrets, merely adding to it an accumulator which will be placed beside it; this will turn a turret of 300 tons weight round its own circumference in three-quarters of a minute. Those plans are already before the Admiralty, and I hope they will be tried as Admiral Halsted has suggested. Seeing Mr. Brotherhood before me, I think the meeting ought to recognize his aid, and that of his partner, in carrying out my plans, and putting them into ship-shape form. One word with regard to what Captain Selwyn has said.—I must borrow for a moment Doctor Croft's fish.—The question of merely shifting the helm is one thing; but I think it must be borne in mind that a fish has got a jointed backbone, which a ship has not. Therefore, we must be content, not having that jointed backbone, to move the rudder in the only convenient way. I hope this remark will suffice for his question. I have nothing further to say than to thank you for the kind attention you have paid to my address, and for the flattering terms in which it has been received.

LUMLEY'S PATENT RUDDER.

By Henry Lumley, Esq., Assoc. I.N.A.

The Lumley-Rudder differs from the ordinary rudder in having a recessed instead of a flat surface; and the recessing of the Lumley-rudder is consequent upon its being made in two pieces, the outer portion making a greater angle than the inner.

The advantage of this over the common rudder has been fully demonstrated in practice under every conceivable circumstance and in every class of vessel, and it has been constantly shown that a rudder, with a recessing surface, is eminently adapted to produce quick responsive action in any vessel to which it is applied.

The sensitiveness of a ship to the movement of her rudder depends on the nature of the resistance of the rudder to the currents of water flowing past the ship as she proceeds onward; also to her form, trim, and rate of speed.

Taking the first feature, the resistance of the rudder, or in other words, the force exerted at a point furthest from the ship's centre of motion, it is apparent, as in the example of the lever, where the more the force applied at the longer end the greater will be the result at the shorter, that the more pounds-weight of pressure of water that is exerted against the rudder, a greater corresponding effect will be produced on the vessel's direction, and as the recessing rudder collects, retains, and locks up the water which also strikes the best part of the rudder at a more acute angle than it would otherwise do, the force exerted and the result produced are both greater than they would be with a flat surface rudder.

There is also the double percussion of the lines of water forming the current, for they first meet the inner part of the recessing rudder, and

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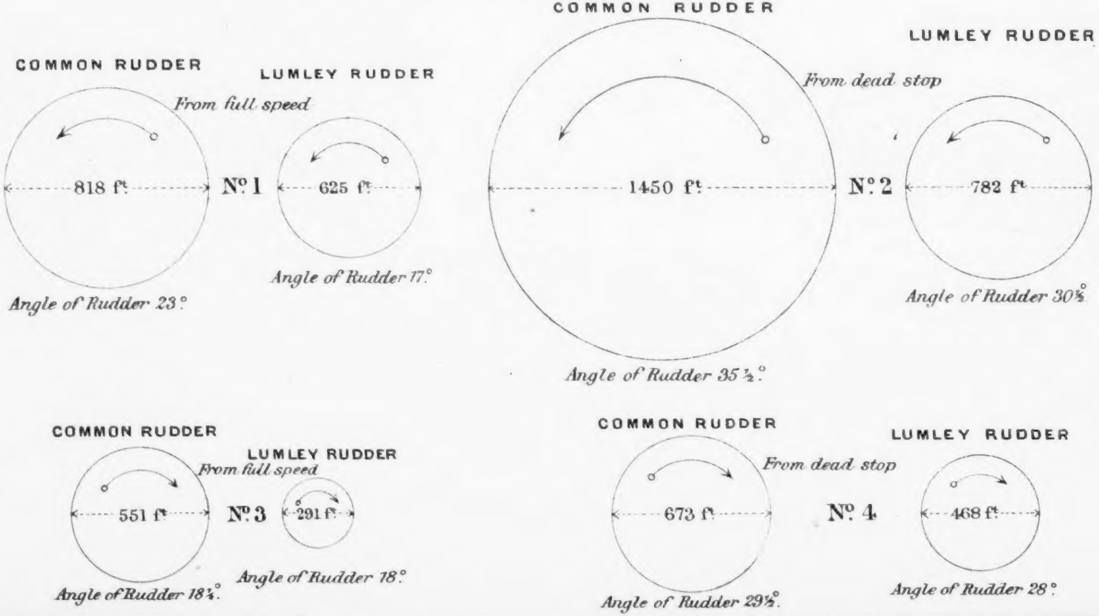
DIAGRAMS of Circles described by H. M. S. Columbine in a competitive trial between the Lumley Rudder and the Common Rudder, showing the differences of the diameters of the circles, the angles of Rudder, &c. on a Scale of 700 F^t to 1 inch.



Angle of Rudder 18¾°.

Angle of Rudder 29½.

FIG. I.

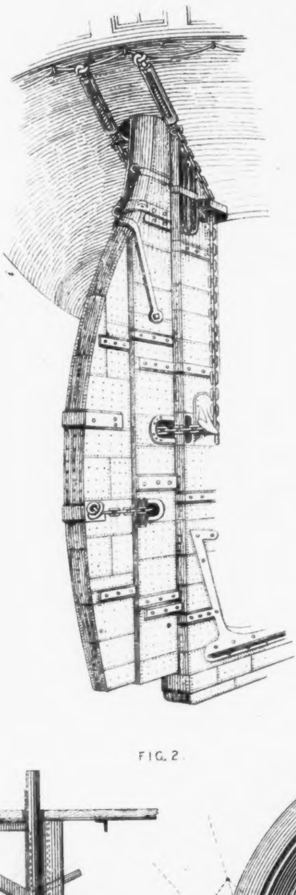
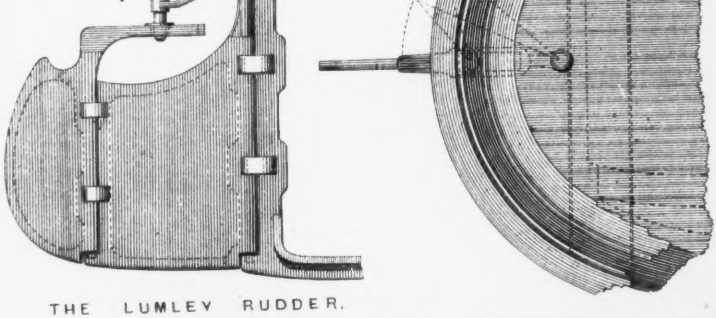


FIG. 2.



THE LUMLEY RUDDER.

Kell, Bro^s Lith. London E.C.

FIG. 3.

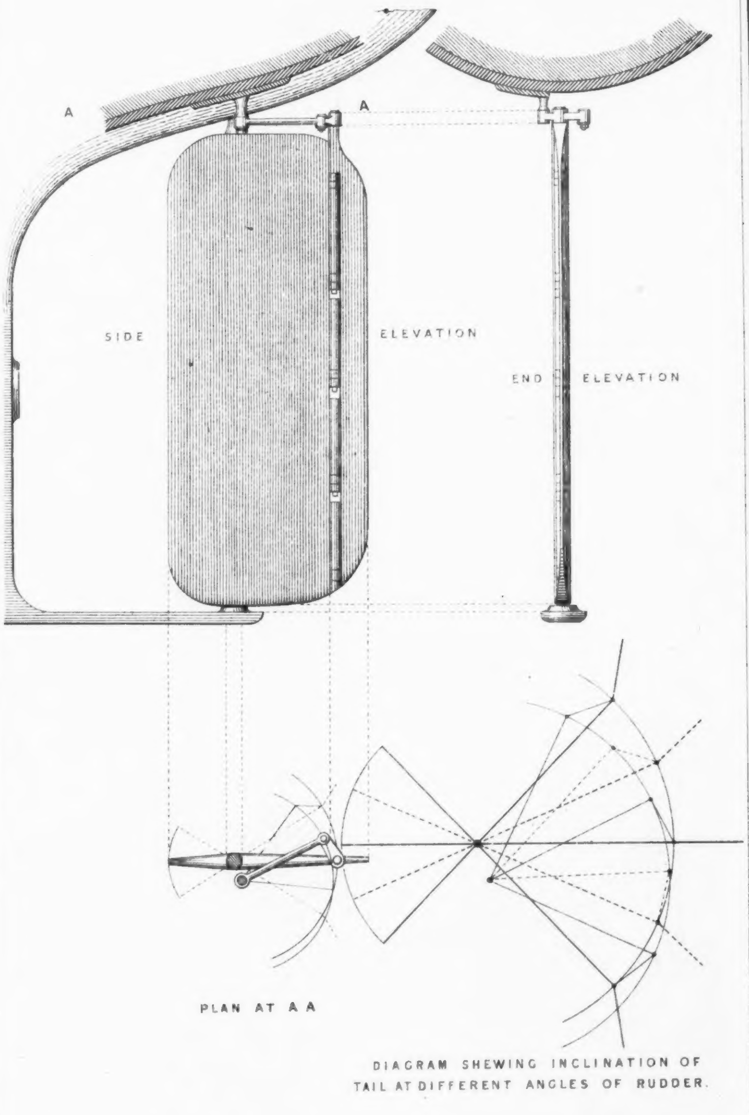


DIAGRAM SHEWING INCLINATION OF TAIL AT DIFFERENT ANGLES OF RUDDER.

THE LUMLEY RUDDER.

Kell Bros Lith. London. E.C.

are then inclined against the outer part, where they strike again; thus is extracted the *vis viva* or strength of the current which, made up of straight lines, is disintegrated and profitably disposed of by means of the two angles of the rudder to which it is opposed.

Experience teaches that a small rudder at a large angle is better than a large rudder at a small angle; and this is apparent because a small rudder is more easily and quickly brought into a position to extract good from the water; therefore the recessing rudder, large or small, yields similar advantageous results, as it permits of its outer piece being brought to an effective angle with rapidity.

In the enumeration of these few easily understood causes, lies a sufficiently tangible solution of the theory of the superiority of the recessing (or Lumley) rudder; but in mathematical reasoning, and in the laws which govern dynamical results, exist concurrent proofs of the value of this form of rudder.

Herewith are appended diagrams (Plate V), by which it is endeavoured to show at a glance the actual value of the Lumley-rudder in a competitive trial with the ordinary rudder; and it may be mentioned that the test of time extending over nearly seven years, and its use in all classes of vessels, from the iron-plated frigate down to the eight-oared racing-boat, show in a remarkable degree the advantage of a rudder of this nature, whether, as it has often been demonstrated, in the prevention of collisions, or under the ordinary and general circumstances of a vessel's career. The first pair of circles were made from full-speed with a starboard-helm; and on measuring the diameter of the circles by the ingenious and accurate method introduced by Mr. Francis Martin, of Sheerness Dockyard, and described in the Transactions of the Institute of Naval Architects, the difference in favour of the Lumley-rudder was 193 feet.

The second pair of circles were made from a state of rest with starboard-helm; the difference in favour of the Lumley-rudder being the very large number of 668 feet.

The third pair of circles were made from full speed with a port-helm; the difference in favour of the Lumley-rudder was 260 feet.

The fourth pair of circles were made from a state of rest with a port-helm; the difference in favour of the Lumley rudder was 205 feet.

Two other pair of circles were made with the rudder at the small angles of 10° and 11°, but no measurements were taken, as the great circumferences of the circles described by the ship fitted with the common rudder, rendered an accurate measure improbable; but there appeared to be a difference, of from one-half to two-thirds, in favour of the new rudder. With respect to the difference in time, it was, in each case, in favour of the Lumley-rudder; the series of six competitive trials showing a mean difference of 42 seconds in each pair of circles.

The vessel in which these competitive trials were made, was H.M.S. "Columbine," 1,000 tons, 200 horse-power; which ship was soon after the experiments dispatched to the Pacific station, where she remained for more than four years, returning to England last year; and from the reports made on her Lumley-rudder during the cruise and on her return, the value of the plan in a sea-going ship has been corrobo-

rated. The Lords of the Admiralty have ordered the Lumley-rudder to be retained in that vessel; and many others in the Royal Navy have since been fitted with it. The applications of the Lumley-rudder in practice is made upon the following systems according to the construction of the vessel.

The first system which is shown in Fig. 1, Plate VI, is the one most suited for the rudders of wooden vessels, and is similar to the rudder of H.M.S. "Columbine."

The second system consists in having a slotted tiller on the tail-piece; this works in a fixed centre, the distance of which from the centre of rudder-head regulates the angulation of tail. Fig. 2 represents this system applied to the rudder of a light-draught river steamer, but it is equally adapted for sea-going steamers, or for the balanced-rudders of iron-clads.

In the third system the head of the tail-piece is fitted with a lever which is connected to a centre suitably placed by a connecting-rod, the length of the lever and position of centre can be varied to give any required angle of tail. Fig. 3, Plate VII, represents the third system applied to the balanced rudder, but it is suited for vessels of any class, whether for sea-going or river purposes.

One special advantage in this system is, that it can, by being properly set out, be made to counteract the tendency in screw vessels to steer less readily on one side than on the other.

The principle can be applied to any rudder irrespective of size or shape, and either for permanent or temporary use. As a permanency, the area of surface of the Lumley-rudder should be less than the common rudder, but for temporary use in special navigation, as in entering rivers or harbours, passing through the Suez Canal, &c., a tail, as in the Lumley-rudder, applied to the ordinary rudder, would be found to be very effective.

Evening Meeting.

Monday, February 21st, 1870.

Rear-Admiral SIR JOHN C. D. HAY, Bart., M.P., C.B., &c., in the Chair.

NAMES of MEMBERS who joined the Institution between the 7th and 21st February, 1870.

LIFE.

Boxer, Edward W. F., Lieut. R.N. 9*l.*

ANNUAL.

Hope, G. R., Commr. R.N. 1*l.*
Thompson, F. E., Lieut. late R.N. 1*l.*
Hill, G. H. H., Ens. late 93rd Highlanders. 1*l.*
Parker, F. G. S., Capt. 54th Regt. 1*l.*
Thurston, W. French, Hon. Asst.-Surgeon 3rd Middx. Art. Vol. 1*l.*
Gun, Henry R., Lieut. R.E. 1*l.*

MILITARY LABOUR.

By Captain C. E. Webber, R.E.

Lately, as a member of a Court-martial, I was much struck by the following incident. Three healthy-looking young men were successively convicted of desertion. Each had enlisted in May, and run away in the following December. They had one and all probably tasted the pleasures of soldiering in a garrison town, and eight months was not too short a time for them to have obtained a view of their future career, by the experiences to be picked up in a Depôt Battalion.

As each case was rapidly disposed of, the following replies were received to the questions as to what they had been doing while absent.

No. 1. I have been working in London as a shoemaker, and I'm tired of soldiering.

No. 2. I was helping in a tailor's shop.

No. 3. My mother wanted support, so I worked as waiter at a restaurant (*Anglicised*).

With the additional remark that each man's character was *good*, I will proceed from suggestive illustration to my subject.

It being recognized that the employment of soldiers on work connected with their existence as a body, is a question which may be called "one of the day," it is less necessary to offer an apology for bringing it forward within these walls.

Although Colonel Synge, R.E., Sir Harry Verney, Captain Sloane, of the Sherwood Foresters' Militia, and others, have spoken on this subject at the Institution on former occasions, I believe that, from a practical point of view, all that can be, has not yet been said on it.

It has required the testimony of these officers, together with the interest taken in the welfare of the Army amongst men in other circles,

to help in overcoming a state of inertia which has hitherto existed, and from which it has arisen, that the experience gained by the real giants in the work has been lost to their successors.

It is a melancholy fact that in very large or overgrown concerns, the most valuable information collected by the only persons who are capable of obtaining it, namely, the executive subordinates, is lost sight of, from the inability to understand the necessity for it on the part of the directors.

Hence we see, year after year, officers of energy successfully producing results which are the means of increasing efficiency and economy, but of which no record is taken. It is true that the individual has gained in experience, and the public may consequently gain, but that experience is lost with his expiration of service. In another sense, the growth of the body is not in proportion to that of its individual members.

Notably in the question before us, there have been Officers of Royal Engineers who have successfully achieved wonderful success, not the least part of their labour having been in combating the impediments they met with in a system of opposition to all innovation or unusual process. And it is to be deplored that it has not been desirable to these officers to leave behind them any record of their manner of overcoming all sorts of difficulties. This, on one occasion, particularly struck me on hearing Colonel J. M. Grant, R.E., describe his success in economy and efficiency of execution of work, by a successful application of a well-directed scheme to the whole of the works at an engineer station under his charge.

Much that has been written or said is too full of theoretical suggestions or mere statement in favour of the employment of soldiers on what may be called remunerative labour, but little of it would be of use to a practical man in helping him to start it, or aid those in authority in forming regulations of a fostering nature.

Public opinion has likewise influenced such writers as Captain Sloane and Major Bolton, whose suggestions, like those of the Committee of the House of Commons of 1862, bear mostly on the improvement likely to arise in the condition of the soldier, a line of argument which is never likely, I submit, to produce permanent action on the part of those in authority, who will naturally, if they consider the question at all, look on it only with reference to its immediate economic results; a view of the case of which I am not prepared to dispute the propriety, unless it is accompanied by a sacrifice of efficiency.

While, therefore, conscious that the employment of the soldier will improve him, I would meet the purely economic view by making it compulsory on him to perform all labour arising out of his existence. Thus: Given a number of men whose being as soldiers is necessary to the State, the question arises, can they, if their time is properly disposed of and directed, perform all such labour in time of peace, whether that labour is consequent on their training and discipline as soldiers, or on the production and maintenance of the necessaries of life?

If it can be proved that this is possible, then it is as incumbent on those who administer this branch of public expenditure, to see that the

labour which belongs to the public service is not wasted, as it is their duty to guard against the loss of any article of public property which labour has produced.

Many writers deal with the work arising out of the status of a soldier under two heads, styling them military and civil. This remnant of feudalism, for it is such, can be traced throughout the whole administration of modern armies. Here and there we find great Commanders recurring to the advantages of an army having learnt to become self-dependent for existence.

There is a strong tendency on the part of undisciplined soldiery to idleness, in which state the man-at-arms of the middle ages kept his attendant, and the sowar of the Irregular Cavalry in India is generally accompanied by his wife; but the reverse, produced in the Romans, the most victorious and the best disciplined armies that the world ever saw, capable of acting in every climate.

As a very poor advocate, I am here to-night to ask this Meeting to consider not only the immediate question of the employment of soldiers on constructive works arising out of their lodgment, but also the general one, that every member of the Service receiving pay from the public funds, whether he be on the active or non-active list, if his time is unemployed or wasted on unproductive labour, is a standing evidence of inefficiency; and that every "so-called" non-combatant member of the army, whether he may be styled military or civil, who is paid for the performance of work while a "so-called" combatant member is available for its execution, represents by his salary a direct waste of public money.

The paper read at this Institution on the 17th January, 1868, by Captain Sloane,* concludes with the confirmatory remark, that the reason of the want of success hitherto, has been, that the subject has not been *placed legitimately before the public as an acknowledged and authorized system of the Army.* In this I am glad to have ground for agreement, although I must point out that his statement of the skilled to the unskilled workmen in the Army being as 4 to 6, is the result of statistics upon the basis of which no reliance whatever can be placed. I am in a position to state from accurate information, that the qualified skilled mechanics in the Infantry of the Line do not number, of all trades, more than 7 per cent.

There is most valuable testimony of Captain Sloane's to the necessity of what he calls an "Officer of Industry" in every regiment—a want which it is hoped the results of this discussion will establish.

His paper embodies all that in a benevolent point of view can be urged in favour of the utilization of the soldier's unemployed time, and is confirmatory of the wisdom of what has been already done in India, and in many regiments, by the exertions of individual Officers. But more than this is required to convince people of business-like qualities, that results will be forthcoming which will repay the cost of organizing and administering, and that the public will be credited with all that now goes into the pockets of persons who contract to perform the same labour.

* See Journal Royal United Service Institution, vol. xii, page 1 *et seq.*

I have read lately with great interest a paper by Captain Beazley, 83rd Regiment, entitled "Suggestions for the Land Transport Service of the Army,"* in which he advocates that the regiment shall be the unit, within a certain limit, for the self-supply of all requisites under the head of transport, food, shelter, clothing, ammunition, and hospital.

But to this admirable suggestion he adds that there is "nothing " military in providing food, clothing, pay, arms, and ammunition for " an army. Even in the treatment of a soldier, either for disease or " wounds, medical not military science is required." On the same principle, there is nothing military in the application of *any* science which war has made subordinate to its uses. Hence Captain Beazley advocates a complete supply establishment for the Army, which, on this ground he styles civil and non-combatant; but at the same time advocates the retention, in their old separate form, of all the departments which have been collected under the Control, forgetting that in this, he is retaining the greatest impediment to his plan of making a regiment complete for all these purposes in itself.

Captain Beazley will, I hope, pardon me if I point out to him that what I think he really means, is. He would have the regiment become self-dependent for all that these local departments, with the assistance of labour from civilians and from other branches of the Service, formerly did for it, and only allow the engineer and supply departments to perform exactly that amount of work which the regimental organization is incapable of. I would add, that such a suggestion as his is incomplete if it does not include a utilization of the labour of Officers as well as of men. Whether sincerely or not, we know that regret is often expressed in the Army, that the work of the junior Officers is not more varied and interesting. In such a self-dependent unit as he describes, the Officers would have to share the superintendence of the work consequent on supply; each one taking up a certain branch under the general direction of the Commanding Officer.

Captain Beazley, I may point out, has also failed to describe how he would propose making this extra work dovetail with the existing state of regimental interior economy; a point on which his knowledge ought to have especially qualified him to judge, and one which I hope will draw out some of the experience of those present to-night in the discussion, to which I am tempted to believe some remarks of mine may give rise.

Lieutenant-Colonel Synge, R.E., in a most valuable paper read at this Institution in 1864, on the "Constructive Service of the Army,"† dwells especially on the probable advantages arising to the soldier from his employment on military works, in making him a more useful man in time of war. It is unnecessary to canvass again the many arguments which Colonel Synge makes use of, as it is probable that most present are ready to concede all that he claims in favour of its extension. In relative importance he places the advantages arising from it as follows:—

* See Journal, vol. xiii, page 564 *et seq.*

† See Journal, vol. viii, page 233 *et seq.*

First. From the military point of view, the effect upon the soldier of employment on military works.

Second. From the constructive point of view, the value of military labour in getting work done.

Six years have nearly passed since the reading of Colonel Synge's paper. If that Officer had been advocating anything new in principle, or stating statistics which suddenly gave wholly unexpected and startling results, it would not be so much to be wondered at, if, like many chimerical projects proposed from time to time, his statements and suggestions produced no effect. Astonishment, then, is not too strong a description of the feelings of the reader and observer of events, when he finds that comparatively few steps have been taken until last year, when the subject was brought prominently before the House of Commons, to give the public service any benefit that might arise from the trial and organized adoption of a system, which, even when Colonel Synge wrote, was well known and acknowledged to be promotive of benefit to the soldier as such, and of direct economy of expenditure.

As after the lapse of these years the decision on so important a matter still shows no signs of having been matured, and things remain almost in *statu quo* so far as anything like real action is concerned, I hope I shall not be considered wrong in asserting my belief that it is an entire want of faith in the probable success of any project for the performance by military means of work now done by civil labour, which has produced the unwillingness that exists to further the scheme; except, by encouragement of a nature too negative to effectually aid the cause. It is true, that any very rapidly effected changes cannot be expected from great public departments. But in those six years we have seen the gradual introduction of various beneficial reforms in Army administration and in improvements for the benefit of the soldier by the costly erection of gymnastics, reading, and recreation-rooms, &c.; but in no case do we find the Army accounts show, that any result has been obtained by the utilization of the soldier's time, to the saving of public money.

There can be no question that large sums, especially on fortifications, *are* annually saved, or, in other words, a very much larger quantity of work than the money would have covered if it was paid for civil labour, has been performed; but the public has not yet seen the statistics. Companies of Royal Engineers and a large number of soldiers of the Line are known to be employed throughout the year; and by indirect means, startling results in saving have become known; but how the public purse is credited with these savings is not shown.

I have only to quote the words of an Officer at the discussion on Colonel Synge's paper, in support of my statement, viz.:

"Under the suggestion of Sir John Burgoyne, with the approval of the Secretary of State for War, and encouragement of the Commander-in-Chief, some of the military works at Dover and Portland are being carried on exclusively by military labour;" and, with reference to a work at Dover, "At the present time two companies of Engineers and a company of the Line are employed in carrying out about three-fourths; and a very large saving is being effected in consequence." Again, "At another station a company of Engineers, assisted by the Royal Artillery

and Line, have been employed completing a work commenced by civil labour. An exact record is kept, and it shows that a considerable saving has been effected."

It is quite open for any one to suggest, that it is within the range of possibility that all the good work thus done is rendered negative by the fact that many of the vices of administration, due chiefly to an obstructive financial policy, so strongly remarked on by Colonel Synge six years ago, are still in full force.

But, Sir, I do not look to a remedy of these (as that Officer seems to have done) as a means for the promotion of the subject now before us; although I believe many Officers are deterred from encouraging it from a fear of finding themselves face to face with the necessity of adapting it to a system of rendering accounts of work done, of a nature so complicated, that it has been hitherto impossible to convince the minds of those who only have the power of reforming, that anything so absurd could continue for so many years to exist.

I find that, for most of my experience of what has been done hitherto, I must quote from statistics of the work done by the Royal Engineers. It will be for my hearers to consider how far these results are applicable in a modified form to the Service generally, with reference to the conclusions I am led to draw from them.

It has been sometimes stated that the employment of military labour is only remunerative on large new works, and that in small repairs there is a decided loss. An investigation of the case, and a very little experience, will prove the contrary, and will show that there can be no good motive in those whose interest it is to keep up the idea. I am led to trouble the Meeting with statistics on this point, as I feel it is of vital importance to the advancement of the "military labour" question that the real commencement should be made on the work which arises daily on the buildings in which the soldier resides, a work which is at his very door, for which I believe skilled labour enough *now* exists within the ranks, and for which, if not done by him, a civilian must be employed.

The statement which I believe goes far to prove that works on repair produce as good results (if not better), as works on large jobs, is as follows:—

At each of two Home Stations works were carried on almost exclusively by military labour, under the superintendence of Officers of Royal Engineers. At the first, the work was of the last-named kind, viz., extensive new works; at the second they were on repairs and small works of renewal. At each, a company of Royal Engineers formed the nucleus for labour, to which was attached for work, soldiers of the Line, both artisans and labourers. The results were as follows:—

	1st Case.	2nd Case.
Average number of Royal Engineer soldiers employed daily	59	53·6
Average number of Line soldiers	98	15·4
Totals..	157	69

	1st Case.	2nd Case.
Total value of the work done, estimated at the War Department contract schedules	£ 9,175	£ 4,690
Value per annum of the superintendence, had the work been done by contract..	360	568
Total by contract	9,515	5,258
	£	£
Actual cost of the work in labour and materials ..	4,636	2,218
Actual cost of superintendence	612	388
Percentage on plant, with current expenditure of same and other expenses	933	30
Total actual cost	6,181	2,636

From this table we get the following results:—

	Shilling.	Shilling.
Contract value of the work per hour of a man ..	1·465	1·028
Actual cost of ditto ditto	·95	·51
Value of percentage saved	35	50

I would recommend these figures to the notice of the Meeting as perfectly trustworthy. They have been compiled from actual results, impartially and accurately taken; and, I need not add, to those acquainted with a year's work of this kind, that they represent no small amount of labour.

It will be seen that the percentage of the superintendence on the expenditure of large works by contract is	3·92
Ditto, military labour	11
On repairs by contract	12
Ditto, military labour	5·8

The agreement in results with actual facts, is a collateral proof of the accuracy of the information on which the figures are founded. Naturally, the superintendence over the day-work of soldiers is nearly three times as costly as that over the work of a contractor where the supervisor has nothing beyond the passing of the work to do. But there is no such coincidence in the works on repairs, which I believe to be a striking proof of what I have elsewhere referred to, viz., the enormous waste of professional labour which arises out of the manner in which the War Office audit requires accounts for such works to be rendered, a form, which although having a business-like character for some purposes, is very objectionable in this, from the difficulty it presents of detecting errors either accidental or intentional, which may arise in its preparation. Instead of, as in the first case, the superintendence of contract work costing one-third of that over the day-work of soldiers, we find it costs more than double, which is, I think, a most encouraging discovery, and an additional argument in favour of the adoption of the

latter system. It can be gathered, that the percentage saved on works in repairs is more by 15 per cent. than on large works, a fact, which, though it may be in part accounted for in these cases by the varying quantities and cost of material used, is also due to an actual economy of labour and material to which the system under which the work was carried on was conducive.

I shall not attempt to enlarge further on the subject of what has been accomplished under the Royal Engineers, as there are others who, from their experience in Canada, at Portsmouth, Parkhurst, and elsewhere, can give most interesting accounts; but I shall in the first instance describe what was done last year by a regiment which undertook the whole of the repairs in the lines which it occupied at the Curragh Camp.

The same might have been done by any one of the six battalions stationed there at the time; but as it entirely depended on the initiative being taken by the Commanding Officer, where no inducement was offered and some trouble entailed, only in one case out of six was there any real work accomplished.

In the summer of 1869 the 1st battalion, 18th Regiment, being quartered at the Curragh Camp, Colonel Call, C.B. (commanding), undertook to execute the fair wear and damage repairs to the buildings in his charge.

For this purpose he drew from the Royal Engineer stores a quantity of tools of each trade as was considered sufficient for the nature of the work.

The regimental monthly inspection having been made, the work on the requisition was detailed by a Clerk of the works, and the quantity of material abstracted from the estimate.

This material was then drawn from the Royal Engineer stores, being credited in the store accounts against the incidental item, and the work was executed.

When Colonel Call reported it complete, the work was measured and the estimate was corrected, to agree with the actual work performed. The value was then calculated from a Contract Schedule (which had been specially prepared) in two amounts, viz., for labour and material. From the value of the material, 15 per cent. was deducted, being the rate at which it was supplied by the contractor. From the value of the labour, 10 per cent. was deducted (being the average local rate), and the remainder divided by 2, in compliance with the regulations, that a soldier shall only receive half the amount allowed for civil labour. The results being added together, gave an amount equal to —, the actual value of material used, added to the value of the soldier's labour. The value of the material drawn by the regiment for the work was deducted from this, and the balance paid on a working pay-bill to the Officer commanding, who arranged his own distribution of it. If there was any balance of material in hand, the regiment drew so much less on the estimate for the next month's work; thus benefiting in money exactly in proportion to their economy of material.

In order that the regiment should be in a position to carry on the superintendence of their own work in future, I obtained the necessary

authority, by consent of the District Commanding Royal Engineer, for an Officer of the 18th, Lieutenant Twining, being attached to the Royal Engineer Office for instruction. This Officer in three months, by giving his whole attention to what was required of him, obtained sufficient knowledge of trades to enable him to look after works in repair in temporary buildings, and will be able to carry them on in permanent barracks, wherever the regiment may be, if he obtains a little assistance at first from the Commanding Royal Engineer. As far as the clerical part was concerned, viz., knowledge of the schedule, detailing, estimating, measuring, and abstracting, Lieutenant Twining was able to perform all that was necessary with the greatest correctness.

The work performed by the regiment in three months, valued at contract rates, was			£27 13 7¾
The value of the material issued to the regiment..		£14 0 5½	
Deduct amount paid to the regiment for the proportion of the above material returned unused into store		£2 2 7½	
Actual material used in the works ..		£11 17 10	
Amount paid to regiment on the monthly accounts	£6 0 5¾		
Above amount paid for material returned	£2 2 7½	£8 3 1¼	
Total cost of work as performed by regiment			£20 0 11¼
Saving to public 27½ per cent.* ..			£7 12 8½

Only 2 carpenters, 1 blacksmith, and 1 bricklayer were employed on this work, with labourers where required, 3 very good tradesmen from the regiment, viz., 1 carpenter, 1 blacksmith, and 1 plumber being employed at the same time on the Royal Engineer works.

It will be seen that the regiment now has a useful nucleus for the extension of the system, and there is no doubt that the present Com-

* The 1-18th Regiment occupied a square at the Curragh during the period described.

The cost of the work for one quarter was..	£20
For four quarters it would have been	80
Add for special repair, which might become necessary, and which could not be done by the Regiment ..	20
Total annual amount required to keep a square of hut barracks in repair by labour of Regiment	£100
Which gives, at 800 men, a cost of, per man	2*s.* 6*d.*
Amount generally expended, and most frequently exceeded, on construction of barracks, vide published War Office returns of barrack incidental expenditure..	6*s.* 0*d.*

manding Officer will not let it fall to the ground. With the addition of a slater and plasterer, he might undertake the execution of all works in repair in any barrack he may be sent to, including the rendering of all necessary accounts.

As regards the square of huts occupied by the regiment at the Curragh, it should be stated that the usual cost for the incidental repairs during the same period has always been at contract rates not less than £70. From this probably much may be inferred, but I think it may also be believed, that less wanton damage to the buildings was done by the occupiers.

The tools and plant used by the regiment were returned into store on leaving. The new regulation, requiring regiments to carry their tools about with them, ought to be altered. First, because no Commanding Officer will willingly increase the weight of his baggage for this purpose; and, second, because it will be just as easy for the Commanding Royal Engineer or Storekeeper at a station to keep a full supply, to be issued and returned, as to keep a certain amount of tools and plant for issue, of those articles which could not be carried about.

But although there is so much to encourage in the accounts I have given, and in a large number of other cases, I fear that too frequently soldier labour has been employed at a loss to the public. That is, that the quantity and quality of the work rendered by the soldiers for their working pay was defective in comparison to what the same amount of money could have obtained of civilian labour. I fear it is greatly due to such examples, that there is a feeling of uncertainty in high quarters of the success of the scheme.

Although there are more than 30 companies of Royal Engineers employed for probably 250 days in the year, in few cases can any information be obtained as to whether their employment is an extravagance or not. Their working pay, together with that of the soldiers of the Line (numbering some thousands) who are associated with them, probably amounts to not less than £60,000.

It would be a startling revelation to find that the same money spent differently could produce better results. And yet this has been going on for years, and no statistics, comparing station with station or system with system, have been produced to clear this doubt. That money has been sometimes saved, at others wasted, is, I believe, undeniable.

But why, you will be inclined to ask, is not the reason for this difference known, and why are not disabling causes removed? I feel, that with so much difference of opinion on these points, the addition of mine will not turn the scale in any one direction. And, although I am here to endeavour to prove to my hearers that *a saving is a natural result*, I am not called on to speculate as to the causes of its failure to make itself felt.

I have said that a saving is the natural result. It is explainable, in that, if a contractor is paid a sum of money for doing a certain work, that sum covers—

Labour.
Material.

Cost of loss.
Interest on plant.
Superintendence.
Profit.

And the employer must have besides superintendence of his own.

If the employer is his own contractor he saves of this; 1st, the profit; 2nd, the difference between two superintendences and the same amalgamated and, 3rd, in the case where the War Department is the employer, the value of all existing shops and plant which exist and must be kept up whether the works are done by contract or not.

Again, in the particular case in point, a saving of a special nature is effected in proportion to the difference between the pay of the civilian and the working pay of the soldier; but only so far as the existence of the soldier is necessary on other accounts, and so long as work of a more important nature is not neglected.

Here we have the sources of very large saving in every case where a soldier is employed during a portion of the time that he would be otherwise idle; always supposing that his being as a soldier is a necessity.

Now it is evident, that by the word "superintendence," is described what is the source of failure or success to obtain this saving.

If work has to be performed by any of our great private firms, which undertake the engineering as well as the execution of much that they do, it is well known by them that all success will depend on the selection of the superintendents, and being chosen, on the good-will and co-operation of these men, in carrying out a most responsible and arduous duty. Care is, moreover, taken, that no unnecessary difficulties, except those consequent on all engineering undertakings, shall be met with. Any loss of profit would be due to defective superintendence, but its defects would arise from negligence in the firm to obtain and utilize the best in the best way.

No individual who has to live on his profit would, for instance, be satisfied with accounts of expenditure which were not the most simple and transparent form of statement. Nor would he waste the valuable time of his superintendents in an office chair, when their real field for the promotion of economy was on the works.

There is a difficulty peculiar to the nature of the superintendence of the labour of soldiers, consequent on the line which has been hitherto drawn between what is styled, occupation *on* duty and *off* duty. It may be traceable possibly to the unwillingness of most Officers to increase their work by any responsibility in connection with what is now undertaken by Departmental corps. I am therefore desirous that this Meeting should take into consideration two points bearing on the question, viz.:—

1. That all labour arising out of the soldier's existence, shall, if entrusted to him to be performed, be considered as much a regimental duty as any portion of his work.

2. That the superintendence of all labour shall be undertaken by the soldier's own Regimental Officer; that Officer, or these Officers, being

compelled to qualify for competency, and becoming wholly responsible for the expenditure.

The amount that will be given to the soldier to perform will then depend on—

1. His competency to perform the work.
2. The competency of his Officer to superintend it.

Under the first of these heads is included (*a*) the question of the soldier's competency as an artisan; (*b*) whether enough labour of a skilled nature now exists; (*c*) how it is possible to make duty of this kind dovetail in the economy of a regiment with what strictly pertains to discipline.

As regards his competency, there is only the question, viz., is it possible to enlist artisans who will have become good tradesmen previous to the age at which it is best for recruits to enter the service, or, is it possible to make a man, who, from his age, has not had time before enlistment to learn enough, to become a good workman afterwards? The experience gained in the Corps where men are enlisted as artisans is here valuable. It is found that men who are already good workers are enlisted; that men become good tradesmen after enlistment; and that the long course of military training which they have to go through previous to their earning working pay, is not deterrent to enlistment. These results are produced merely because the work has to be done, and, where they are stationed, Sappers have to do it. Produce the same necessity for any other Corps, and you will find that the works on repair which are always occurring, will be done by Regimental artisans instead of civilians as a matter of course, and that the execution of these works, if properly superintended, will give an opening for these men to improve in their trades, and for others to learn.

That enough of skilled labour now exists in the service to enable a regiment to undertake the repairs of its own barracks I am led to believe from a few facts I have collected. At the Curragh Camp last year:—

The average number of Non-commissioned Officers and men, including sick (of all arms) was	3,094
Of the eight infantry battalions stationed there during the year, the percentage of men declared as belonging to the building trade was	3
After strict trial, the percentage found competent was	·75
Of these, the average number employed daily, of artisans were..	8
” ” ” ” of labourers were	25
(At the same time, the percentage of men of the building trades in one company of Engineers was)	(77)

Neither Cavalry nor Artillery were required to declare the numbers of their tradesmen, nor could they have done much work during the short drill season if they had.

The above figures give nearly six skilled artisans per regiment

of the building trades, exclusive of the pioneers, who, in many cases, were good tradesmen, but were not lent to the Royal Engineer Department.

Again, at Aldershot, where the strength last year was about—

Cavalry, 4 regiments,
Artillery, 7 batteries,
Royal Engineer Train, 2 troops,
Royal Engineers, 2 companies,
Infantry, 12 battalions,

there were found to be of men nominally belonging to the trade of painter, 114.

In the mounted corps, out of 40, 18 were declared available for work, from three corps only. Of the Infantry and Engineers, out of 74, 64 were available; 82 men in all, 10 being Royal Engineers.

Of the remaining 72, according to previous results, probably 18 would have been fair workmen, which, with the Royal Engineers, would have given a body of 28 painters to do the work of the camp.

Now, allowing that the drill season lasts 17 weeks, and that these men could have been employed 3 days a week for 8 hours a-day, we get $3 \times 17 \times 28 \times 8 = 11,424$ hours of a man, which, at the Aldershot contract rates, represents an expenditure of £628.

But the expenditure at Aldershot per annum on repairs and small works is about £6,466, or £2,114 for 17 weeks. Out of this, from calculation, I conclude that £125 is spent on painting. So that there remains an available force of labour for painting purposes capable of performing work of the value of £503. Thus, out of the 28 men, 5 could have been employed on painting and in repairs, and 23 have been employed on new works.

Again, at Brompton Barracks, Chatham, where the whole of the incidental repairs are carried out by the labour of Sappers who are situated, as regards regimental duty, pretty much as other soldiers, there are 3,620* days of an artisan employed at this work in the year. This barrack is one in which an exceptional amount of work is necessary, and particularly so in proportion to the number of occupants, and yet, only calculating at the occupation numbers in effectives and horses, the days of an artisan required is 287 per cent. Or, in other words, 2 per cent. of the occupants working $143\frac{1}{2}$ days in the year can keep the entire School of Military Engineering in repair.

* These 3,620 days are apportioned nearly as follows to the several trades:—

Bricklayer	544
Mason and Plasterer..	363
Slater	180
Carpenter and Joiner	1,265
Locksmith and Blacksmith	709
Painter and Glazier	203
Plumber	152
Gasfitter and Bellhanger	204

That these men are in many cases but recruits, is additional evidence of the feasibility of immediate action being taken to establish the same everywhere else.

(2.) With reference to the competency of the Officer to superintend the men's work, much may be said of what exists and might exist. It may be asked: What is the nature of the superintendence? What amount of technical instruction is required to make a superintendent? What is the nature and form of the accounts to be rendered? How is the superintendence to be paid for? And in reply to these questions, I would say, that a man of a constructive turn of mind, with some slight previous knowledge of trades (of which many exist in the Service), could soon qualify himself to look after work of the nature required in repairs and small works. And that with a simple system of rendering the accounts, and a position and pay analogous to that of Musketry Instructor, Officers in every regiment would be found ready to undertake the duty. The acquirement of knowledge, and the opening given for the development of industry for the benefit of the Country and the Army, being an additional inducement.

The Officer of Industries might be selected for his qualifications, and from his having attained a certain standard of knowledge in the Architectural course at the School of Military Engineering, Chatham. When officially recognized, he might be distinguished in the "Army List" by some prefix. He should be under the rank of Captain, unless able to perform both duties. His regimental duties might be confined to attending only the same parades as those at which the artisans under him were obliged to be present. He ought also to take his share of garrison duties, guards excepted. Under the Commanding Officer's directions, he would make the usual monthly inspection of barracks to note damages and repairs. Immediately under him, but still belonging to, and falling in on parade with, their respective companies, would be placed the regimental artisans, of the following trades:—1 carpenter, 1 blacksmith, 1 plumber, gas-fitter, and bell-hanger, 1 bricklayer, 1 mason and stone cutter, 1 slater, 1 painter and glazier, each of these men being specially qualified and known by distinguishing badges, and replacing the present pioneers. These should be exempt from all duty but certain defined parades.

Knowing the qualifications of all other tradesmen in the regiment, and men available as labourers, the Officer of Industries would daily arrange with the Adjutant for the services of assistants to the regimental artisans, according as his work laid out for the next day required it. After a little experience, the roster for regimental duty might easily be arranged, so that all the men of one trade should not be taken together for any single duty.

The Officer of Industries will not be long in acquiring the power of forming an opinion as to whether a lock has been properly repaired, a broken slate replaced in an efficient way, or a piece of flooring put in in a workmanlike manner, and by degrees his knowledge will extend to understanding all the details of joiners', carpenters', smiths', and other artisans' work. With him will rest the charge of all tools belonging to the regiment, or drawn from the local stores, and the

keeping of the accounts arising out of the expenditure on works, and he will be the medium of communication between the Commanding Officer and the Engineer and Control Department, for all transactions arising out of the occupancy of barracks or other buildings.

Although the superintendence of works in the conservancy of dwellings is only here alluded to, it will also be found that other industries, such as tailors, saddlers, armourers, &c., will naturally come under his direction.

I have already sketched in my account of the work done by the 1-18th Regiment the manner in which I propose the accounts should be kept. As a permanent check on the expenditure on repairs, I would propose in addition, that the accounts be certified to, monthly, by the District Commanding Engineer, for payment. Hence it will be necessary for that Officer to have the value of the work done in the period assessed at *soldier schedule* rates, in order to ascertain that the amounts for labour and material, which he is asked to sign, do not exceed that value.

The Commanding Royal Engineer's duty will then be confined, in respect of repairs, to—

(1.) Quarterly or half-yearly inspection of the buildings, for the purpose of ascertaining that they are not deteriorating from neglect.

(2.) Monthly correction, before execution, of the requisition or list of repairs taken down by the Officer making the inspection, to prevent work being undertaken which would cause an excess on the annual authorized expenditure.

(3.) Monthly inspection and assessment of the work performed, previous to certifying to payments, when he will guard against passing work of too extensive a nature, or such as has arisen from damage or neglect.

(4.) Inspection of the barrack at the period of transfer, when he will take down all kinds of repairs not made, and entering them in one list, will assess their value, and, treating them as a charge caused by neglect against the outgoing regiment, will hand them over to be executed by the incoming.

It will be seen by this regimental system, that the corps in some respects occupies the place of a contractor for the work, only at schedule rates which exclude all payments except for labour and material.

A schedule, based on the existing ones in use by the Royal Engineer Department, can be easily made by persons acquainted with the nature of its construction, which will give, against all descriptions of work, in two columns, 1st, the value of labour at soldier rates; 2nd, the value of the material.

I may remark, that there is some resemblance between this and the course occasionally followed in France, where the soldiers of a regiment are allowed to work under a contractor on the repairs of their own barracks, either by the day or by the task; except, that the contractor pays the State for their labour at civil rates. The latter only gives the soldier two-fifths of that amount, retaining the remainder, which is

carried to the credit of the expenditure on military works, and shown as a saving produced by military labour.*

In estimating the amount of clerical work necessary in the superintendence of incidental repairs, it is often lost sight of, that the amount of money expended is no guide.

It is easily understood that, apart from new works, the labour of direction must be estimated by the *number of transactions*, not by their value in money. Thus at a place where the average value of a transaction is 7*s*., and £700 a-year is expended on repairs, there is very little more labour in superintendence and rendering of accounts than at a station where the value is reduced to 1*s*., and the expenditure is £100 per annum.

Each transaction represents an item in the requisition for repairs, whether the requirement be the taking down and re-setting a boiler, or merely the re-fixing of a thumb-latch. Their value may vary between £5 and five farthings, but the superintending process is nearly identical in time and writing, irrespective of the value.

In the London Royal Engineer District, these transactions, in 1868, amounted to 11,240 in number, at an average cost of 8*s*. At the Curragh camp, in the same year, there were 9,860, at an average cost of 4*s*. 4*d*.

Having given some idea of what would be required of the "Regimental Officer for Works," it becomes necessary to make some proposition for his payment, in order that his position may be sufficiently improved to induce him to exert himself.

If 2*s*. 6*d*. were the amount per diem of extra pay, it would amount to £45 12*s*. 6*d*. per annum for each Officer. But as in a Battery of artillery and a Regiment of cavalry, the amount of work would vary from that in a Battalion on account of the extra wear and tear in stables, the remuneration might be made on a different scale, so as to adjust itself to the amount of the work to be done.

Taking the strength of the corps as a basis of calculation and not the expenditure, and counting horses as individuals, but excluding women and children, I propose that the superintendence shall be paid for at one shilling a-head per annum.

If the cost for repairs per annum amounts to an average of 6*s*. a-head, there can be no question that if the present actual cost of the superintendence due to the same could be arrived at accurately, it would exceed 15 per cent., raising that amount to 7*s*.

But if military labour produces a saving of 30 per cent. on the 6*s*., the total expense will be reduced to 5*s*. 2½*d*., or a total saving of 1*s*. 9½*d*. a-head, amounting to a sum not less than £12,300 per annum on the total strength of men and horses on the British Establishment.

But as, in fact, the ordinary and current repairs to buildings at home and abroad were estimated last year at £201,875, and the establishment for the same year, including horses, was 137,230, we find an expenditure of £1 10*s*. 8*d*. a-head. If by our first means of calculation

* Vide Memoire de l'Ingénieur Militaire, par *Grivet* Capitaine du Génie, page 181.

we arrive at a result which reduces this sum by 30 per cent. to £1 1*s*. 6*d*., which, with the proposed expenditure, amounts to £1 2*s*. 6*d*., we get a saving of 8*s*. 2*d*., or £53,700 per annum. It is probable that the real sum to be saved lies between these amounts, viz., £33,000.

At Brompton barracks, Chatham, there is evidence of the saving being fully up to this, although for want of an estimate of the value of the work at contract rates, its exact amount cannot be ascertained. The expenditure on incidentals amounts to 6*s*. 3*d*. on the construction, and 9*s*. 4*d*. on the occupation, including the unusual addition of a large proportion of Officers' quarters, an extensive mess establishment, with special schools of instruction, besides stores and sheds not usually attached to an ordinary barrack.

In concluding the subject of superintendence, I am desirous of pointing out a very considerable saving that would ultimately accrue, in the necessity not occurring for the elaborate system of accounts hitherto employed, which takes up the valuable time of professional men in the Royal Engineer Department on wholly unprofitable labour, a system which I have already referred to in terms which can only be justified in view of the example I propose giving.

I have in my possession a copy of a War Department triennial contractor's bill for incidental repairs, amounting to £1,016.

The requisitions on which the work was done were ..	219
Items or transactions therein	1,967
Entries for estimate, including a calculation in each ..	5,724
Signatures of names in full	1,752

In this first stage is included a visit, to see what had to be done in each of the 1,967 transactions; followed by the issue of 219 written orders on the contractor, containing the complete details of the estimate in the same number of entries, viz., 5,724.

In the second stage, the work being completed, a visit to each again, and a measurement registered, contained in 259 pages.

Entries of measurement, including a calculation in each, 5,170.

Third stage, an abstract of the 5,170 results of these calculations on 67 large sheets of paper.

The abstract sheets contain—

Headings copied from the schednle	614
Abstracted quantities, each entailing a calculation ..	3,702
Columns of figures added up	1,418

The effect of this abstract has been to group the 5,170 entries of measurement under 614 heads.

Last stage—the copying of the 614 transactions into a bill in duplicate, calculating out the value on each, and adding up.

In theory this is all done at the same time by the Contractor as a check, but, as a rule, he finds it more expeditious and economical to trust to the Royal Engineer Department calculations.

Thus we have for an expenditure of £1,017—

509 documents, containing
1,687 pages of written foolscap,
25,547 separate entries, mostly consisting of several words and a calculation in figures, and very nearly
1,800 signatures.

Further, the paper weighs 1 lb. 15 oz. which, with an expenditure probably of £150,000 by contract labour on repairs for the year, gives a weight of 290 lbs., half of which is so much waste paper.

Difficulties in the way of such an organization as I propose, may be expected to be met with in several directions. In the case of Commanding Officers, by a want of co-operation, or by opposition, either of which would materially interfere with success.

In the changes consequent on the Control Department having been inaugurated, we find that the charge of the building in which his corps is located, is to rest entirely in the hands of the Commanding Officer, who becomes the lessor, the Royal Engineer Department acting as house agent, and the Control Department as the furnisher. This is really a very radical change on old institutions, and an advance more than half way to the desired end, for the repair of a building is closely allied with its charge.

It is proposed that the Officer Commanding shall originate monthly requisitions for repairs, as now, but that he shall send them for the inspection of the Commanding Royal Engineer, as before described, and then hand them to his "Officer of Industries" for execution. Immediate and urgent repairs he can perform at once, sending on the document to the Commanding Royal Engineer afterwards.

I think that Commanding Officers will soon find that the advantages are so great in the rapid execution of work, and in the improvement of their men, that, as has happened in the Marines, all who have begun by opposing the scheme will soon give it their cordial support.

The system of "Musketry Instruction," which has now become part of the necessary work of a soldier with such good results, at first was much opposed and thought little of; and it had not the advantage which is now offered, which will ward off much criticism, viz., of being no additional source of expenditure.

The same nature of difficulties may be met from the possible unbelief of those whose position enables them to promote the success of such an undertaking. There may be an idea, that work of this kind cannot be made obligatory. Influences which have personal reasons for the continuance of the present system, may be brought to bear adversely. The details of arrangement may be framed by those who have peculiar views not founded on general experience, and possibly the Accountant's (or, as some call it, the financial) part of the question, which so often mutilates a good measure, may leave an impression on it that will effectually make all chance of success out of the question.

From the soldiers who would fill the position of artisans, no opposition need be looked for, except to the necessity of appearing on parade

in their places in the ranks for inspection and drill at least once a-week. There might be unwillingness to aid in training other men in trades, but this could be counteracted by a system of payment which would offer a premium, in every case of a man having become a qualified artisan under their instruction. There will be complaint at first on finding that the men working with them are taken away for their turn of other duties, or in case of punishment, but from my experience of this, where it has been carried out most strictly, it is a difficulty I believe which habit will soon counteract. In every regiment there will be men who, either from disinclination or bad character, yet smart, clean soldiers, will never be available for work. All grumbling on their part must be disarmed, by taking care that no extra duty falls on their shoulders in consequence of the employment of their comrades. In the natural course of things, we shall hope to see the number of idlers and bad characters decrease. I think it will be found convenient, in most regiments, to make the work of tradesman's labourer an ordinary fatigue, to be supplied from the usual roster for that duty. Artisans receiving pay for their work by the piece, will find it best for themselves to give their labourer a trifle, making the duty popular, and giving the man an insight into the trade.

In mounted corps (it will be said) such a proposal is not feasible. Commanding Officers of Cavalry regiments have told me that they cannot spare a man, and yet we find others stating that their painters could be spared forty days during the drill season at Aldershot. But I anticipate eventually as encouraging results from these as in any case. That the Cavalry or Artillery soldier has time, in addition to his other duties, is proved from the example of the Royal Engineer and Military Trains, in which the men give sixteen or twenty hours of work a week, and yet turn out in perfect order on all occasions. Again, there is less tendency to idleness amongst these men than in the Infantry. And, lastly, I think we shall get the full co-operation of the Commanding Officers, when they find how readily and quickly damages in stables will be rectified, a great source of inconvenience when delayed, as they too frequently are.

The example of the Cavalry barracks at Colchester, which is very complete in every way, is instructive. The average occupation, including Officers and horses, is 914. The average yearly expenditure on repairs, £280. As the material for the repair of this barrack is likely to be very expensive, the above sum would probably not be reduced by more than 20 per cent. with soldier labour, viz., to £224; which, by the Brompton barrack results, represents 1,940 days a year, or 6 days per cent. on 543 men each week.

There are two other sources of difficulty, more serious than those already referred to, viz., in the case of small detachments, and that arising out of sudden and constant moves. Time and necessity can alone be looked to as a remedy. If the system becomes compulsory, these difficulties will be foreseen and provided against; if not, they will be made the excuse for doing nothing. I look very much to the establishment of an "Officer of Industries" to help in overcoming these. He will endeavour, in the case of detachments, to provide

for the work, by seeing that the building trades are distributed as equally as possible in each company. And he will soon be able to instruct the master artisan in each company sufficiently to enable him, with the help of the local representative of the Royal Engineer Department, to do the simple clerical part of the business. Sudden moves, from one old tumble-down barrack to another, as in Ireland, will be given as examples when the troops could never carry out the work. In such cases as, where moves are long premiditated, there must still be an official inspection by the Royal Engineer Department at the time of transfer. At this inspection (as I have already proposed) all *neglected* repairs are to be treated as damages, being paid for by the out-going, and executed by the in-coming. It seems to me that this will work as well in the one case as in the other. It will be always open to the Inspecting Officer to modify his interpretation of the word *neglect*, to cover any unavoidable difficulty arising out of the suddenness of the route. But as soon as the work becomes a regular weekly duty, there need be no arrears of petty repairs, which will be executed from day to day as they arise.

It will have been gathered that I am an advocate of the Regimental system of work. I confess to have been at one time strongly opposed to it, believing that no work could be successful unless the men were placed entirely at the disposal, and under the supervision of the local Royal Engineer Department. From personal experience, and from reports which I have collected on all sides, I have been led to change my mind. As a rule, Commanding Officers grudge their men to the Royal Engineers, and there need be no wonder at it. Where the regimental organization and that for work, are under one head, no difficulties need arise. In the case where they are separated, difficulties, in spite of the best endeavours to the contrary, will occur, resulting in want of economy, and finally in a total abandonment of the mode of working, as hopeless. Of course I must not be understood to apply this to the cases where large bodies of troops are specially employed on large works of ordinary labour.

I am anxious, in concluding, to impress the Meeting strongly with my conviction, not only on this point, but also on the necessity for its becoming a recognized part of the system, that duties which carry with them a special remuneration ought not to be allowed to interfere with those which are obligatory on all. I have narrowly watched the working of both ways, and although I have often seen harm arising from making exceptions in the duty of men specially employed, I have never seen any detriment or real inconvenience in a rigid adherence to the rule I advocate. At any rate, if, as I have proposed, the master artisans are to have immunity from certain duties and parades, their status, as privileged men, should be defined by regulation.

I trust, Sir, that the Meeting will understand, that in confining my observations to one branch of industry only, I have really had the interests of the general question in view, firmly believing that all the parts of the machine are actually in existence, and that all that is wanted is the power to put them in gearing, and set them in motion.

Mr. Edwin Chadwick, C.B.: I beg to make some observations upon this very important and interesting paper which Captain Webber has read, because I think I may supply somewhat of what appears to me to be a deficiency of principle in the motive power, namely, the element of self-interest of the workers. I have had some experience in relation to military labour; to trained and systematised military labour, to that of the Ordnance Survey Department, where, as I think, the defect of a deficiency of interest in the work, and its consequent slackness, even under a highly-trained superintendence, was strikingly displayed in connection, particularly, with the Engineer Corps. Some years ago, when as a Sanitary Commissioner, and member of the first General Board of Health, I had to promote sanitary works for the improvement of towns, I was strongly induced by my friend General Colby, who had charge of the Ordnance Survey, on account of the representations which he made as to the superior eligibility of the Engineer Corps, to press the services of that corps upon the local authorities to make the requisite surveys for their drainage works. One ground for my doing so was, that the employment of the Engineer Corps was, as he represented, much cheaper, that their surveys would be better, and the corps having a superior division of labour, could be made more responsible for the work than could possibly be the case with civil engineers. The work must, he urged, be much cheaper, because the privates, the chain men, the Non-commissioned Officers, and the Officers, worked at some half the daily pay that civilian engineers could get trained men to do work for. With this case,—which was all set forth in black and white,—it was a pleasant duty to urge the employment of the corps upon local work. I encountered the hostility of civil engineers, but a number of towns began with the Ordnance corps. But the work, instead of being quicker, was, with all the division of labour and disciplined superintendence, dreadfully slower than the civil work. This was a most serious disaster to our board, as it prevented our having the works of several foremost towns completed, as they might and ought to have been, as specimen towns, to show what might be done, in time to submit to Parliament, when the period arrived for the renewal of our powers. The failure in point of time was a public disaster. But when the bills did come in, they were greatly beyond what we had been led to expect them, in some instances more than double our estimates and more than civil engineers were ready to testify they would have done the work for. Towns refused to pay these demands, and defied battle before juries upon them, and I believe that they never did pay the excess beyond the estimates. The *morale* presented was that which is the opprobrium of the building trades, of enormous bills beyond the estimates, on the faith of which the Service has been included. Now what was this disaster due to? To day work. True, the men were paid at half the rate by the day that civilians were, but they took two or three days to do the work that the civilian does in one. Since this lesson, as I understand, the piece-work principle has been introduced, and I am assured that, under it, twice and three times the amount of work is now got for the same money. I have seen a great deal of work done by soldiers, and my observation leads me to say that the piece-work principle is of very general application, and of special necessity for application to their labour, if you are to get out economical results equivalent to those from civil work. In the instance of the survey work, the superintendence was systematized. In civil work—in railway work, for example—what constant superintendence would get out from the navvy twenty cube yards of earthwork a day, the gang's "stint," that piece-work gets out? The military superintended-day-work is the ridicule of workmen of the wage class. I happened to be going down the river, and looking through a glass at some work going on at Woolwich, a workman came beside me and said, "Will you let me look through your spy-glass?" He looked, and saw a soldier painting something; when he said, "There is a day work stroke;" and handing the glass to another operative, he said, "Isn't it, Jem?" "Yes," said he, "it is indeed a day-work stroke, and a very poor one of the sort." Operatives, in going about and seeing soldiers at work, speak of it with ridicule; they stop, and laugh and chaff the soldiers at the way in which the work is done by them. A contractor proposed to reconstruct the huts at Aldershot of concrete and other materials, and declared he would get it done cheaper than the Government or the Army

could do it, and yet he would get it done by the soldiers, if he were allowed to employ them. He would do it, but the officers could not. "And how would you do it?" I asked. "By piece-work," he replied; "I would soon get them into the way of it." What a spectacle had we, and Europe, of our sending out a civil works corps to construct a road, whilst there were spadesmen in the ranks who saw their brother navvies doing the work at six or seven shillings a-day, which they in the ranks could and would have done if they had been allowed to do it at piece-work! I am confident that if that common principle of self-interest were duly brought into play, you might have an enormous amount of public work done by the ranks of the Army. Let the work be put up to contract to be done at piece-work by the men, and I believe they would form themselves frequently into gangs, or with their Officers to overlook them, and would do the work at a great deal less price than the work could be done by civilians. The piece-work principle is applicable to Officers as well as men. If any public work is required, let the Engineers' Officers of any rank send in plans and estimates for it, and if the plans are accepted, let the planners have the execution, with a percentage on the results; and let them engage the men at piece-work to do it. On this principle much might be got, with great advantage to the public as well as to the Force. But the paper does not develope one topic which I think of very great importance with respect to Army work, namely, the out-door work—letting the men out to do civil work. The cases of the men tried by court-martial for desertion, cited by Captain Webber, are illustrative of the topic. They were men of good character. One of them said, "I have been working in London as a shoemaker, and I am tired of soldiering;" that is to say, they were wearied of the barrack routine, and desired not idleness, but work. Well now, might we not let the men out upon long furloughs to do civil work for themselves to a very great extent? Why, in the case of the Engineers themselves, I observed some evidence of Colonel Kean to the effect that they had from those highly-paid men frequent desertions; and the cause of the desertions was, that there was some special civil engineering work to be done close at hand, for which the men get, for the time, seven shillings a day. The men of otherwise good character, probably like those mentioned by Captain Webber, deserted from three shillings a day in order to get seven shillings. Why should they not be allowed to go on furlough, even at some inconvenience to get that money, and return? Why should we not let men go out on long furloughs who are "tired of soldiering," that is to say, of doing nothing, or only wearisome, and wasting, and enervating routine work, and find profitable employment? Why detain them in the purgatory of a monotonous, wearying routine, when they would probably return gladly periodically to exercises of active interest, such as volunteers enjoy? That is done abroad—in Sweden, for one example, as I know. I know at one time it was done here. In my inquiries as a Commissioner of Poor Law Enquiry, and afterwards in Poor Law administration, into the causes of pauperism, I found that the Army contributed a heavy contingent of pauperism, and that the disbanding of a military force was attended by an addition to the pauper force, the pensioners included, a great portion of the pension-money being almost worse than wasted from the mode in which the pensions were paid. I found Army pensioners a regular item in almost all pauper rolls;—so regularly, that on looking over one roll, in one of the suburban parishes, I said, "You have not got any pensioners on the pauper list; have you no pensioners in your parish?" "Yes, we have," said the parish officer; "but the pensioners are old Guardsmen; they have been used to work in the Service, and now they are pensioners they continue to work, and they get their own living." I was struck with this incident, which directed my attention to the subject, on which I made official representations. There are Continental examples of the practice—that of Sweden I learned most about, of letting men who can find work for themselves go out on long furloughs, with the condition of coming under colours for a part of the year, to keep up their exercise; being an extension of our Militia system. In Sweden, about two-thirds of the force is frequently out on leave, to the great relief the country and the benefit of the men, and with anything but detriment to the effective force. If the men of good character who deserted, from being "tired of soldiering," and returned to productive

work, had been let out on furloughs, they would probably have gladly returned to the ranks for a part of the year, as a change from civil work, or on account of any slackness in it. On such a system, which would be better than the usual short terms of recruitment, you would get a far higher and better order of recruitment than you now get. In the instances of which I have had accounts, the men engaged in productive work are really fresher and stronger for service than those who are kept in barracks, in camps, and cantonments, where they are comparatively enervated and demoralised, as the penal returns and the hospital returns show. Such is much of the experience of Prussia, as well as of Sweden and of the Northern States of America, where there will be no lack of force when the trained men are brought again under colours. In Sweden, as I am informed, so systematically is the principle applied, that there are nearly two-thirds of the first regiments always out on furlough. In a city like Stockholm, if a merchant ship comes, and it is required to be unloaded immediately, they go to the guard-house and get a sufficient force; it may be a corporal's guard, or a company with a serjeant, and the ship is unloaded in a very short time. The guard-house is a sort of labour mart for getting a great deal of the miscellaneous labour of the town, and I have no doubt a larger amount of the miscellaneous work in this metropolis might be done in this way by soldiers better than by the Commissionaires. The men would find out work for themselves which nobody else would find for them. The principle of letting out men systematically for civil service would, I submit, be equally applicable to Officers, and especially to Officers of the scientific corps for any length of time, only calling them under colours for short stated periods to maintain their professional habits. I think the restraint to this, by the present practice of seconding, of requiring Officers to leave active and invigorating and profitable civil work, and practise in the direction of labour, and return to inferior barrack work or no work, and only enervating routine, is proved to be pernicious and indefensible. In India, as well as in America, active civil occupation, and productive occupation, in peace, is proved not to deteriorate but to augment aptitudes for work in war. In the Northern States of America, after continued trials, they were driven to the scientific corps for commanders, and of their successful and most distinguished Generals I believe there was not one who had spent an exclusively barrack, or camp, or cantonment life, and who had not been engaged in some sort of productive civil work in time of peace. As an all-prevailing principle, that of piece-work is to be contended for in the Service as the prime mover, and systematised, and the most free permission to occupation in private service. These principles I venture confidently to assert, from experience and observation, would conduce to our military force, as well as largely to the public economy.

Colonel Schomberg, C.B., R.M. Artillery: I should like to say a few words upon this subject. I think in so interesting a question, facts are what we want. During the last three years I have had an opportunity of having a great many men at my disposal; I speak now of the Marine Artillery. I have not had the returns of the work done last year, but in the years 1867 and 1868, out of an estimate by contract of £6,500, the soldier-labour made a saving of nearly £1,600, about 25 per cent. The work was very various. The barracks were repaired and kept in good order. Two batteries were thoroughly repaired to represent sections of ships. One battery to carry a 12-ton gun, and two 6½-ton guns; the other, lighter guns. The guns were pivoted and placed there. One or two stores were roofed. The main drain was extended. New schools were half built. When the reduction of the corps took place, I was obliged to remove the men from the schools in consequence of requiring them for drill. A parade ground was made and levelled, and various other works were carried out. I will give you a list of the tradesmen employed. A superintendent serjeant (who received extra pay of two shillings a day), bricklayers, plasterers, masons, stone-sawyers, carpenters, slaters, smiths, plumbers, glaziers, fitters, painters, white-washers, labourers. In the laboratory, other repairs were carried out which are not included in this return. Military machines, gun-carriages, and platforms, &c., were repaired, employing wheelwrights, armourers, and others. A theatre has been constructed entirely by the men—scenes painted by the officers. I believe a Frenchman says a soldier's duty is to wait and brush his clothes. I think while he

is waiting, a good many of these works might be done. Moreover, while these works were being carried out, the usual drills were not interfered with; and we embarked 600 men last year. But I think that no system for the employment of military artificers can be carried out thoroughly without localizing corps and regiments. I do not think you will get any system of work or instruction in regimental schools into satisfactory operation until this change takes place. However, that point is wide of the present subject. But I am certain you will never get good work from the men, nor will you ever train them as efficient workmen, until the corps are localized.

Dr. Stallard: I desire to make one or two observations upon this subject as a civilian, and one who probably has seen a little of various organizations in different parts of the country. If Colonel Schomberg had not alluded to the Marine Artillery barracks at Portsmouth, I was about to allude to them as strong evidence of what may be done by military labour. Still, great as is the work there, and admirably as it has been done, I must say that I think there is still more to be done. I think Colonel Schomberg has hit the main point; it is this, that unless you localize the regiments, you will never be able to carry out any great system of work, the men will have no interest in it. It appears to me that there are one or two other points which have not been alluded to in the paper, which I regard as preliminary to anything like a general system of employment in the Army. I have* elsewhere pointed out the absolute necessity for providing something more domestic in the character of barrack accommodation for the soldier. I believe without privacy and something like domestic life, it is impossible to give the soldier the necessary motives for acquiring property, and for really benefiting himself and his own social and moral position. I do not think that with the present mode of life there are sufficient motives presented to the soldier for working really. I also thoroughly agree with what has been said by my friend on my right (Mr. Chadwick), that all work in the army must be done on the principle of piece-work. I have often, like him, observed and smiled at, as a civilian, the way in which, for example, a fatigue party goes to carry coals from the stores. About twelve or fourteen men are sent to do what two or three would very well accomplish if they are paid for it. A corporal and a certain number of men go along, and as soon as they turn the corner of the parade-ground, they set down their baskets and begin to chat. They often stop two or three times. I have often seen this at Aldershot. It is not an unreasonable thing for them to do; the men have no interest in what they are doing, therefore they do not hasten over it as they would do if they were paid for that work. I maintain, therefore, that no system of employment will ever succeed unless it is a regulated system of compensation for actual work done. Then, there are other things which stand in the way of work in the Army even far before this, and which I do not think have been sufficiently noted in the paper before us. I allude to the notion of what is necessary in the shape of discipline, parades, guards, and sentries. Now I must say, as a civilian, looking at it from a civilian point of view,—I daresay gentlemen will pardon me, I know these are perfectly heretical opinions for me to hold,—but it struck me certainly in two or three cases it was a ridiculous sight to see an Officer with a guard of twenty men at a place like the entrance to one of the barracks at Dover. There is an ascending staircase, there is an Officer's guard there of some twenty men. I ask you whether any gentleman thinks it necessary to employ twenty men and an Officer to do the business of that particular place? It seems to me a waste of human labour to keep up men for the purpose of doing certain routine work, keeping them up three nights in the week from their beds, for doing what would be infinitely better done by two paid men. I take the example of the Royal Factory at Woolwich. I believe two policemen take charge of the gate. There are many thousands of people who go in and out during the day, and there is a great deal to be done, and two policemen do all the work of that gate. I have seen men standing over a gun at Dover in the same useless manner. And the worst of it is, it seriously interferes with

* On the Construction of Barracks in relation to the physical and moral Condition of the Soldier.

anything like continuous labour; it is these little duties which interfere so much with the useful and continuous employment of the men. I do not deny that a great deal can be done, as shown by the Marine Artillery and the Royal Engineers. But at the same time I am convinced that before anything advantageous is done, there must be some alteration in the notion that it is necessary to keep a soldier at a continual round of little irritating duties. There are some other points which I should like to have mentioned; but I think we shall all agree that it is absolutely necessary we should have some change in this respect. I believe nothing would so contribute to the health and the general popularity of the Army, as to really give men the opportunity of going into it for the purpose of getting genuine employment, and to do real work for which they shall have a fair amount of pay. Let men come in for a short period, and they will come in in times of emergency, and they will get a moral and physical training, both in matters such as have been brought before us to night, and in various branches of trade. I hold it is perfectly competent for a regiment, and should be the business of a regiment, to provide itself with every possible thing for its own internal economy, clothes, boots, and all the necessaries which may be required. I hold it to be perfectly possible to do so. It has been demonstrated in the case of the Marine Artillery, which Colonel Schomberg has told us of. There, in addition to doing all these things that he has mentioned, the men have a large amount of time for enjoyment; they have billiard-rooms and other things besides. I do think the money of the country will be better expended in making some attempt to cultivate useful labour than in setting up gymnastic play-grounds, which teach the men to do nothing. I do not wish to make any improper remarks upon the gymnastic play-grounds; at the same time I should be sorry to see them placed before the question of real and honest hard work. I do believe if that were done there would not be the same need for gymnastic buildings. I think if the same energy and the same money were devoted to really turning the industry of the men to account, the country would get the advantage.

Colonel FLETCHER, Scots Fusilier Guards: There are a few words I should like to say on the subject of Captain Webber's interesting paper. I have gained some little experience during the last few months by watching the course that has been pursued with reference to military labour by a portion of the second battalion of the Scots Fusilier Guards at the Tower. During the time the battalion has been stationed there, many of the men have been employed under the Royal Engineers both as mechanicians and as labourers, and not only do I think the labour performed has been to their advantage in the way of discipline, but the medical officers have mentioned that in consequence of the men being so much employed in the open air, their health has improved. The battalion has also attempted another mode of labour which I think requires some notice. The men have been instructed in the principles of field engineering; they have been employed in the Tower ditch in throwing up portions of redoubts and of batteries, in making gabions and fascines, in constructing portions of the first and second parallels, and in other works comprised under the term of "field engineering." In this way their time has been fully occupied.

Sir WM. CODRINGTON: Were they paid?

Colonel FLETCHER: No, certainly not. The men were selected for the work, two from every company, who when the course had been completed, were relieved by two others selected in the same manner, and as a proof that the men liked the work, I would mention that there were many volunteers for it. I have seen the men working in the Tower ditch with hands blistered and sometimes bleeding, and yet there was no grumbling; on the contrary, the men were interested in what they were about. It was something new, and at the same time they felt that they were learning their duties as soldiers.

I see a few difficulties in the way of employing soldiers in trades. One is the jealousy it might excite outside. The mechanics are jealous of soldiers working at trades, lest they should take the bread out of their mouths. Another difficulty lies in providing suitable clothes. If men have to be frequently on parade, where they are expected to be perfectly smart and clean, they do not like to get their clothes dirty. There is also this difficulty, that there are a great many men who enlist into the Army who are constitutionally idle, and who have been forced to enlist from

their unwillingness to work in any other way. These men are not necessarily bad soldiers. They may very likely have been fast sort of fellows who would not put their hands to hard labour, and have consequently joined the Army under the idea that there would be nothing to perform.

To turn to another portion of Captain Webber's paper, he alludes to the project of appointing an Officer to superintend the trades. The description of duty that such an Officer should be required to perform, ought I think to be extended.

I think there should be in every regiment an Officer to take charge of the "field engineering." The infantry ought not to be dependent in time of war upon the Royal Engineers for instruction in the ordinary requirements of "field engineering." An Officer ought to be in charge of the "field engineering" as well as in charge of the trades. And one or more good non-commissioned Officers ought to be instructed as foremen of works.

An observation was dropped by a gentleman just now with regard to the advisability of permitting the men to go out and do work for themselves during the time they are serving as soldiers. In a minor degree this has occasionally been done by allowing the men to take part in the harvesting. There is another observation I should like to make before sitting down. At the Guard's Institute a short time ago, the plan was tried of instructing soldiers in trades. A room was fitted up, carpentering tools were furnished, and a man was paid to instruct; but the scheme was not found to answer. The reason was, that the men had to dress and go out of barracks in order to get to the Institute, and consequently would not take the trouble to change their uniform for a working dress or fatigue jacket to learn a trade. If you want a soldier to learn a trade everything must be perfectly easy to him; men must work in the barracks, and they must see that there is remuneration for their labour. I think an attempt is going to be made to have the minor repairs in barracks done by soldiers. One difficulty I foresee is, that there may be some slight objection to the men who are employed as tradesmen being struck off duty. Still, when men see that they are charged less for barrack damages, and that barrack repairs are done cheaper than under the former system, they won't greatly object to their comrades being struck off duty to insure such results.

Captain Colomb (Adjt., Limerick Artillery, late R.M.A.): With your permission, Sir, I will make one or two remarks in reference to the paper before us. In the first place I wish to endorse Captain Webber's opinion with regard to the voluminous documents required in connection with military work. I would supplement his illustration by reference to the very case quoted by Colonel Schomberg, of repairs done by the Marine Artillery. These repairs were done by our own men under the superintendence of a serjeant. That serjeant was under a civilian clerk of the works, who received a guinea a day; he, in his turn, was under another civilian engineer of the dockyard four miles off. A lock in my company-room wanted repair. I had to send to the Field Officer of the week a requisition involving my signature; that requisition had to go to the Commandant, it involved his signature; it went to the barrack master, involving his signature; it went to the clerk of the works, it involved his signature; the clerk of the works entered it and sent it down to the dockyard, four miles off, and at the end of a fortnight—it came back. I sent the requisition for this lock in January; I repeated it every month till May, and it was repaired on the 21st June. The cost of that repair was 1*s.* 8*d.* As I understand Captain Webber's proposition, his scheme at present simply applies to the ordinary barrack repairs. As I understand him he wants to increase the number of pioneers as it were, supplementing them by men of certain trades capable of executing these repairs, the whole being under the superintendence of an Officer. If I understand it rightly, that is the proposition. As far as it goes I must say I think everybody will agree that it is perfectly feasible and possible, and must be productive of economy. Colonel Schomberg alluded just now to what had been done on a larger scale in the way of new works. I think Captain Webber and most officers will agree with me in saying, that it is very unlikely, as long as there is no sort of localization in the Army, any works on an extensive scale can be undertaken by purely military labour. With regard to the observations made by the first gentleman who spoke, and who advocated giving long furloughs to soldiers for the purpose of enabling them to follow out their particular

trades, I would remind him that abroad where they do that, the soldier is tied to his regiment by something more than the mere enlisting shilling. He serves in a part of the army which is as it were grafted on particular districts of the country; his whole civil connection is in a particular district; therefore, in letting him out, as it were, or allowing him to take furlough to execute work, of course he goes and obtains that work where his civil connection exists, which is in the district where he enlisted, in which district, in point of fact, he entirely serves. In our Army we enlist a man, say in Edinburgh, the regiment probably moves to every garrison town in the United Kingdom; it perhaps goes to Malta, from Malta to India, from India to China, and from China it comes home, and by that time the man has no civil connection, and the chances are that if you let him out, you will never see him again. That is my firm belief. All these questions, apart from the mere execution of ordinary barrack repairs at home and abroad, open out to my mind a much larger question than that involved in the paper—I mean, the remodelling of our military system.

Mr. CHADWICK: I did not understand that in Sweden there was any relation of the kind between the man and a particular district. Men went anywhere. Of course they would probably go home and seek for work in their own neighbourhood. I may ask if there was any such connection with the district when the Guards were let out in London. I forgot to mention that they had to pay some share of their earnings to other men for doing their duty, and I believe something was paid to the officers as well, out of which they kept up a table, and that altogether the amount of earnings was considerable.

Sir HARRY VERNEY, Bart., M.P.: I think, Sir John Hay, we are extremely obliged to Captain Webber for originating this discussion, and for the many interesting statements which he has made to us. I think it is very often the case that the discussion is still more interesting than the paper, and on this occasion the remarks of gentlemen who have had experience, and who have been so good as to give us the result of their experience, have been particularly valuable. I hope very sincerely that we shall never be prevented from employing soldiers in labour on account of any jealousy that may be entertained by civilians. It appears to me we should consider what is best for the Army and best for the whole country, and I cannot believe, although certain tradesmen might feel some degree of jealousy because soldiers are employed in work, that that would have any sensible effect upon the minds of those with whom the decision of a matter of this sort must rest. With regard to the work that can be done by soldiers, I was once visiting a friend in an army of 40,000 men. They had erected all their own huts, they built a theatre for themselves, they painted the scenes; each hut contained, I think the number was seventeen men, and many of the huts were ornamented with drawings made by the men themselves; in short, they provided themselves with their own residences and ornamented them, and one day an Officer who conducted me took off a man's shako and said, "Except the ornament on this shako, all the man's clothes were made in the barracks. That is an instance of what soldiers can do. Napoleon used to say that his best Army—it was the Army that conquered at Wagram and Austerlitz—was the Army that had been three or four years at Boulogne, and which there had to provide everything for itself. It was the most working Army, I believe, that Napoleon ever had. Colonel Fletcher has referred to the capacity of Officers to superintend work of various kinds. I confess I think our Army will never be what it ought to be until our Officers are capable of many of those duties that Colonel Fletcher has alluded to. On service it may often happen that a young Officer is placed in some positions in which a knowledge of field fortification and of throwing up field works at very short notice, must be of the greatest possible importance. My own idea is, that no man ought to be allowed to be an Officer unless he has some degree of knowledge, not only of field fortification but also of military drawing. I do think that every Officer in the Army ought to be able to describe on paper intelligibly the relative height of hills, and which hill commands another; to describe also the ground where artillery can act and where cavalry can act; in short, to possess a certain amount of knowledge of country. This is the very first knowledge which every Officer who aspires to rise in his profession, ought to possess. I should like very much to hear from some military men present, what they think of the proposition of the

gentleman on the other side. I have long had the opinion that it is at the root of Army reform, I mean short service. I have long believed that it would be desirable to get men into the Army for a short time. We almost all of us know families where there is some young fellow who, if he could be a soldier for a few years, say four or five years, would gladly come into the Army. The discipline would do him a great deal of good, and he would leave the Army young enough to begin any trade or business or profession, and would be much the better qualified for it. If a system of that sort were carried into effect, I believe that many a young man, perfectly well fitted for it, would consider it a great benefit to be allowed to enter into the Army for four or five years' service. If you allowed only those who had some military spirit and taste, and who, therefore, would desire to remain connected with the Army to enter the Reserve Force, you would, in the course of a few years, have the most powerful Army and the most powerful Reserve in the world. A French General writing lately upon our service, said the "English infantry was the best in the world." And he went on to say, "Happily for us there are so few of them." They did not want so many English soldiers. For my part I do not desire a larger Army, but I do desire that our Army should be efficient, as efficient as an Army can possibly be. I think this discussion ought not to terminate without our returning our thanks to a young Officer of the Navy, Mr. Hanbury Tracy, who has been so kind as to bring this subject before the House of Commons. I am a witness that there was never a better exposition made in that House than that made by my friend who sits on my left, of the great advantage of military labour. I certainly hope he will pursue that subject which he has so well commenced, and that his efforts may be of advantage to the military service.

Colonel SCHOMBERG: I should like to say one word about the much maligned Officer. There seems to be an idea that our Officers are not equal to the Officers in other services. I think it is a pity to think so. All I can say is, as far as my experience goes, that if I want an Officer to build a theatre, or paint scenes, or manage a workshop, I find that our Officers can do it.

General Sir WILLIAM CODRINGTON, G.C.B.: Many points have been mooted which are excessively interesting to military men, but none more so than the one mentioned by Sir Harry Verney, which is the foundation of the well-being of the Army, namely, the term of enlistment. You cannot expect, if a man enlists for ten years, that at the end of the ten years he shall be fit for other business when he leaves the Army. If he enlists for five years, and is a young man of eighteen, of course, at the end of his term, he can go back to his village and learn some trade or calling. But then comes the great difficulty, for this is only a casual part of the question, and as Sir Harry Verney has referred to it, I think it may be worth while to refer to it again, how is your Army distributed? Your have 60,000 men in India; you have a certain number in the colonies, say 16,000 or 20,000 men. Your cannot treat these in the same way that a foreign Army is treated, which is specially located in its own country.

A VOICE: It should be a separate Army for India.

General Sir WILLIAM CODRINGTON: It is not so now; and that question is not at present before the House of Commons. At present reliefs are sent out to India, and, of course, it is a heavy expense to the country, this perpetual renewal of the Army there. Therefore you cannot apply the same principles to the Army of England that you would to the Army of Prussia or the Army of France, which countries possess comparatively no colonies, and where the Armies seldom leave their own districts. There were one or two points mentioned with regard to piece-work. We will go into that question independently of the more abstract business of the Army. Is it to be understood that piece-work can be carried on without good superintendence? Impossible.

Mr. CHADWICK: No, it was not said so.

Sir WILLIAM CODRINGTON: Surely it requires, except for rough earth work, the most efficient and detailed superintendence for piece-work in order to see that it is properly done. Every single bit of material, and every single bit of work, must be good. Is it possible to ensure skilled superintendence and good work out of the Officers, and out of the men as you enlist them now? I doubt it. If you are to have work, I see no

reason why you should not let the men do day work, with proper superintendence on the part of Officers who are qualified for it, viz., principally Officers and N. C. Officers of Engineers who have charge of that particular department, the barrack department, the repair department, and all those works in which the soldier can be employed. It is a good thing for a regiment to have as many artisans and labourers in its ranks as possible; and not only that it should have these men, but that there should be constant work found for them, so far as it can be done consistently with the military necessities of the regiment; for we must never ignore the military necessities of a corps. Take India or take the colonies, there are military duties to be performed there which it is impossible to neglect. Now let me refer to the twenty men on guard at Dover mentioned by a gentleman opposite. Those twenty men on guard furnished probably six or seven sentries. Does the gentleman know where those seven sentries are stationed? There are kitchens, there are walls which the men must not get over. At the entrance gate there are sentries; I don't know the total, but we must allow that the Commanding Officer at Dover would not put on one single sentry that was not necessary. Therefore I doubt whether you can do away with a certain number of men on guard, because there happen to be seen twenty men here or twenty men there on duty. Sentries must be found; for without sentries the men get out of barracks; all sorts of things might happen in stores, cook-houses, and elsewhere, details which those connected with regiments well know. Therefore the objection of that gentleman does not apply. I am very glad to hear from Colonel Fletcher about the instruction that he has given to many men of the Guards, and still more gratified to hear how willingly they have taken to that instruction without payment. We all know that the soldier, generally speaking, does not like work, and one is delighted to hear of the men of any corps wishing to improve themselves in the actual work of their profession. There is an old saying in the Army among soldiers, "Why, if I wanted to work hard at digging, I need not have enlisted." That is the sort of feeling which prevails, and one is gratified to hear that this feeling has been overcome, to a certain extent, by those who wish really to improve themselves in their profession. Some Commanding Officers object to habitual working parties for their men, because, liking to have them smart and set up on parade, they think it interferes with these qualifications; but I am sure those who have been upon service feel that the regiment which is best fitted for a campaign is the one that has been most accustomed to work. Any person who has been on service will see the difference between soldiers who have been at even a common peace-camp and those who have been in no camp at all. That is the mildest way in which you can make the comparison, and I have myself seen a regiment arrive on foreign Service perfectly incapable of pitching its tents, not knowing where to get its fuel, or how to use its fuel, or how to make its kitchens; whereas, the regiment which has been in a peace-camp, even for a short time, is able to do all these things. Therefore labour is everything in an Army, and I hope Commanding Officers generally will feel that the more it is attended to, the better for the regiment upon service, because, after all, efficiency for real service is the point we must look to at last. I quite agree that the term of enlistment should be shortened. If you have a short term of enlistment, you can insist upon men doing things which you cannot with a ten years' service. Not only that, but another result can be kept in view, that if a man can come in at eighteen, you need not provide all that complicated system which is necessary for the married soldier. It is an enormous expense and an enormous inconvenience. Every regimental Officer knows, on the movement of a battalion, what an inconvenience it is, what miserable scenes take place with men in debt and men married. You could at once settle that, provided the men enlisted only for a short time. But then comes the question of expense. If you have 60,000 men in India, and you can only send out these men for four or five years' service, see what expense it must be compared with a ten years' service. However, that is a question we may well leave to the philanthropy of the House of Commons; that is to say, to those who really have power over the soldier's well-being; it lies at the very basis of the whole question of Army Reform.

Dr. Stallard: Will you allow me to explain? It appears to me, with respect to the number of men employed upon guard and sentries, that there are already the

widest differences between various regiments under various circumstances. In the Marine Artillery, for example, there is an extraordinary small number of sentries and guards. I found also in a regiment at Portsmouth there were only three persons employed as sentries in the whole regiment. The Officer said, I would rather have no walls to my barracks. He said, "I don't consider it necessary to have walls and to treat my men as school-boys; I never have, and never shall." As far as I could make out, there was no relaxation of discipline. On the contrary, I know that that regiment was capable of making all its own clothes and doing all its own work; and, probably, it did as much actual work as any regiment in the Service. But when I know that when a sewer has to be flushed, or a privy to be emptied, it is absolutely necessary to call in the contractor to do it, which is the case continually, and when I know that the Commanding Officer will not detail men to sweep the dirt away, it appears to me that system is carried to an extreme.

Sir Harry Verney: I would add that men enlisting for five years will have no pension; that will be a great reduction of expense. Also I would say that I moved for a return of the amount which one battalion of the Rifle Brigade had earned in India. Sir Hugh Rose was so pleased with that battalion that he made it a present.

General Lord Napier of Magdala, G.C.B.: I would beg leave to say a few words. I don't know if I am infringing the rules by speaking here without previous notice, but having had some experience in the working of soldiers, I can fully corroborate what has been said as to the advantage of employing them. I also think some remarks are necessary with regard to the circumstance mentioned by a gentleman who spoke of the twenty men on guard at Dover. With regard to the working of soldiers, that, perhaps, has been practised more in India than in this country. I remember very well Her Majesty's 13th Regiment being employed in a hill station. The Engineer wanted to remove a number of hills; he gave the work over in contract to the soldiers. They looked very hard at their bargain; they measured the hills, and they considered the matter for two or three days before they would take the contract. They got their oldest heads to examine the contract, and when they had satisfied themselves, they took the contract for better or for worse. They did their work perfectly, and were all the better for it. There are now many miles of road in the Himalayas which have been made by soldiers who are employed there every year. An amount of labour has been obtained which could not have been taken from the civil population, for the people are not very fond of work, and are jealous of any interference, so that by the employment of soldiers a great advantage has been gained in a military point of view, by connecting two military stations by a line of mountain road. With regard to native troops I can speak with great confidence, because I have watched the labour of these men. It was formerly the custom to canton the regiments in India, and to make them build their own huts. No one took much pains to see what sort of huts they built. They were built in regular lines, and very miserable huts they were. But with the gradual progress in sanitary improvements, better huts have become necessary, and the men have been engaged to build them. The class of natives in India which supply the soldier, does not like labour. They are often able to put forward religious objections to labour, but they work in their own homes, and the man who in former times would have refused to take up a spade or a basket at the order of his Officer, might have been seen in his own home covered with mud in making his hut. Still they were allowed to put forward the religious objection. But that has now been very much done away with, and they have been engaged, particularly in the Bombay Presidency, in making their own lines. The expense of labour in that Presidency is very great, and at the same time the cost of all materials has risen very much. The soldiers were therefore told, "If you will give the labour, we will give you the materials, if you cannot buy them, for the sum allowed by Government" (it was rather a small sum). For each set of lines there was an estimate made by the Engineer Department, and I found, upon calling for a statement of what had been done by about thirteen regiments, that the work was accomplished for £80,000 under the estimate. The men have been stimulated to great emulation, and have built very nice lines indeed. Some of the native Officers' houses that I went into instead of being mere hovels, which they used to be formerly, are really now very nice abodes, and very comfortable inside. With regard to what has been said about twenty men

on guard, very apposite remarks have been made by Sir William Codrington; but I think it might be further stated that the whole education of an Army has reference to a few days comparatively of its existence. Its whole existence is an education for the day of battle, and it is impossible that an Army can be efficient, which neglects, in time of peace, those duties that it is called upon to practise at a moment's notice in war. The soldier in peace has to be on guard, he is taught the paramount importance of being watchful, trustworthy, and vigilant; he learns that if he goes to sleep at his post, or if he disobeys orders, or allows a person to pass that ought not to pass, he is subject to punishment. That gives him the habit of "discipline." I think that explanation might prove satisfactory to gentlemen when they think they see soldiers playing at duty.

Colonel EVELYN, Commandant 1st Royal Surrey Militia: As instances from experience seem to be received with interest this evening, I may as well state another fact concerning a regiment that has already been honorably mentioned, the Rifle Brigade, in which I formerly served. A good many years ago on the frontier of the Cape of Good Hope, many of these excellent measures which now excite so much interest with reference to the employment of the soldier, were put into practice. The first battalion of the Rifle Brigade built a town, they built excellent barracks, they built houses for their officers, some of "wattle-and-daub," some of bricks, and roofed with various materials. They also made an aqueduct some three or four miles long to supply the camp with water, and for the purpose of irrigation. When we left, they had more than half built permanent barracks of stone. That was all done entirely by one battalion, without neglecting any of its military duties. Colonel Glyn, who has already been mentioned, was at that time a Captain in the regiment. Our Commanding Officer, poor Sydney Beckwith, gave no unnecessary drills. We had a daily parade, inspected arms, &c., and saw that the men were in proper order, and then dismissed them to their working parties, and almost the whole of the regiment was employed almost every day in working parties. I never heard of a single man objecting to work, although their extra pay was very small, about 4d per day. They preferred this to lounging about in the barrack-rooms. I think it unnecessary to make many remarks about the number of men on guard after what we have heard from Lord Napier of Magdala; but I think at the bottom of the shaft at Dover, the main guard of the town is posted, so that in addition to furnishing sentries, it has to take charge of prisoners, therefore sometimes it would not be safe to have a small guard there. Still I agree with the gentleman who made the objection that we have too many sentries as a rule, and though it is necessary to have sentries in order to teach men their duty on guard in time of war, I think it is a great pity that the number of sentries is often so great as to injure the soldier's health. That I fear is the case in London and in many other places. If you go to that old brick building, called St. James's Palace, which can hardly be considered a royal residence, you may see, from the middle of a back yard, no less than five sentries within a stone's throw of each other. What can we want with so many? We have enormous banks in Lombard Street, we have the most magnificent shops filled with costly works of art, and we have no sentries there, and what can we want with so many sentries round St. James's Palace? It is the same with many other places. At the same time it is most important to post young men as sentries; I have done it myself often, in order to teach them their duties.

Colonel EWART, C.B., R.E.: It is getting somewhat late, therefore I would limit what I have to say to a few words. As a Commanding Royal Engineer, I should not like this discussion to close without saying something upon the subject, especially upon some points which have been adverted to. I think we ought to return our thanks to Captain Webber for the trouble he has taken in getting up this paper, and for the valuable statistics which he has collected; because these statistics prove what may be done. The question of piece-work has been adverted to, as if there was something new in it. In every rank in the corps of Royal Engineers, I have been somewhere or other engaged in the employment of military labour. I can only say that if my friend Mr. Chadwick had been at Gibraltar with me twenty years ago, he would have seen me at six in the morning going to the works and laying out tasks for the men. The men, if employed by task-work in that climate, are able to get away from the

works earlier than would otherwise be the case, and are thus less exposed under a hot sun. Therefore, there is nothing new in the idea; we have worked by task-work in the Engineers; we have worked by piece-work, and we have worked by day-work. The key of the position in the matter under discussion is this, that, in order to carry out this system effectually, the Commanding Officers must be with us. I may mention that I and other Commanding Officers of Engineers are most anxious to promote this sort of employment for the troops. We find it answers where we get the Commanding Officer to take it up and work it. You have heard what Colonel Fletcher has said this evening. The work he has described happens to be going on in the district of which I am the Commanding Royal Engineer. Therefore, I can endorse what he has said as to the way in which that work has been done by the battalion to which he referred. This work was begun when Colonel Fletcher was in command of that battalion, and no doubt his example and his superintendence were mainly the causes of that work succeeding so well. Captain Webber has spoken of a regiment where the scheme has been perfectly carried out. I am sure we in the Engineers are quite ready to do everything in our power to see this system adopted, but we want the Commanding Officers to be with us. Something has also been said on the subject of road-making. I would just make one remark with regard to what was said about road-making in the Crimea, although I speak with some diffidence in the presence of Sir William Codrington. At the time of the siege, when there was a great want of road-making, there was also a great want of men. When the siege was over, there was no difficulty in making roads. It was about that time that the Army Work Corps arrived from England. The Army Work Corps brought out a great many highly paid carpenters and highly paid smiths. They all looked very comfortable. They all brought out a great deal of porter, which they were always ready to drink. But the main work of these roads was done by the soldiers. I think I may say there were 10,000 men employed upon those roads per day.

Sir William Codrington: For a short time 10,000 and 7,000 men.

Colonel Ewart: The advantage of the Army Work Corps coming out at that time was their bringing out these artisans, these highly-paid carpenters, &c.; these were the men we wanted.

We had many artificers in the Sappers at the beginning of the siege, but at the end of the siege the numbers were greatly reduced. When the siege was over, our men were employed in road-making and draining, and in supplying many other wants experienced by the troops. The difficulty with regard to piece-work in reference to the question which Captain Webber has brought before us is this, Captain Webber has mainly spoken of barrack repairs—barrack repairs are small works. After a time you may perhaps be able to establish a schedule of prices, and pay the men by this for each thing that they do: still this must be the result of experience. It is much more difficult to establish such a schedule with regard to these small odds and ends of barrack repairs, than it is with regard to large works such as navvies execute.

Lieutenant-Colonel Chesney, R.E.: I will only follow what Colonel Ewart has said upon the subject of piece-work by adding that, in 1847, I was employed on a military work under the late Sir William Gordon, with a number of engineer soldiers and convicts, altogether about 300 men. Every man worked on piece-work. But in 1857 I worked with a civilian contractor, who also employed 300 men, and every one of those men worked by day-work. I mention the facts to show that it is an illusion to suppose that civilians always work by piece-work, and the Army by day-work, as one of the preceding speakers would imply.

Sir William Codrington: I do not know whether I am in order speaking a second time, but I will not detain you long. It is in reference to the Army Work Corps, referred to by the last speaker (Colonel Ewart). I have heard many people say, "Oh, when we have another war, you will find all the work of the Army will be done by a civilian corps sent out with the Army." I have said, "I am very glad to hear it; it will take a great deal of work off the hands of the fighting portion of the Army; but you will find a great difficulty in the way of discipline." And I cited the experience of the Army Work Corps. What has been mentioned this evening is in corroboration of it. The Army Work Corps came out in the midst

of the first winter in detachments, before I was in command, though subsequently I had a great deal to do with them. The first operation they had to do on the plateau of Sebastopol was to put up tents, and make themselves comfortable. That was no easy matter for them; an immense quantity of time was naturally occupied in housing themselves in these tents and huts, and getting themselves to rights. It is quite true that when the war was virtually over, they were employed in making the main road from Balaklava to the front; and being a limited number, of course the troops had to be employed, and they were employed; 2,000, 3,000, 7,000, and at one time 10,000 soldiers worked at that road, between six and seven miles in length. It is certainly not the case that the road was made entirely by the Army Work Corps. The country was at an enormous expense for the Army Work Corps: 5s. a day per man, rations, and clothing. Supplies of all sorts, not only of necessity, but of convenience, perhaps luxury, *quasi* a soldier's life, such as large chopping blocks such as you see in butchers' shops in England, which were provided for the use of the Army Work Corps in front of Sebastopol. Plumbers were sent out; for what purpose? We had little to do with pipes and cisterns. Many were artisans at 7s. 6d. a day—no man less than 5s. a day—besides rations, clothing, tents, and stores. They were not engaged to go under fire; they were not employed in the work of batteries or trenches; and after the south side was taken, it was doubtful, for this reason, whether they could be employed even in re-making the road into Sebastopol. They were not under the Mutiny Act till 1856, and the statement was put to me by the Superintendent, "If you will not put them under the discipline of the Mutiny Act, I cannot keep them in order." "No," said I, "I cannot do it; I shall only be brought up in a civil court in England. But if they come into my camp, and cause disturbance or an absence of discipline there, I shall take care that they shall be punished. Mr. Superintendent, you must keep your own people in order." "Well," he said, "I cannot do it." "What does your discipline consist of?" "Fining." "Nothing else?" "No." "Then you had better go home and tell your own story, for I cannot help you as to that." Although the Superintendents were very good men, many of them men of ability, and in the Corps were several good workmen, if it had not been for the assistance of the Army they would never have made the road to which the last speaker referred.

Colonel LOWRY (47th Regiment): As Commanding Officer of a Battalion of the Line, and thus one of those who have been so frequently referred to by the lecturer to-night, may I be permitted to express my sense of the importance of the subject which has been brought before us? Captain Webber has referred to some of the difficulties to be encountered in the endeavour to harmonize a system of Military labour with Military discipline, and the duties and requirements more essentially appertaining to regimental life. He has mentioned several, but I am not quite satisfied that he has fully disposed of them, and I think a good work remains to be done by any one who not only notes the difficulties which may be expected to arise, and especially at first, but who, as far as possible, provides for them. I think the difficulty of dove-tailing a system of Military labour, such as the lecturer has indicated, into the every day life of a battalion, is considerable; but I feel sure it is not insuperable, and I rejoice at every effort to clear up a subject so full of importance to the public service and to the soldier. I feel satisfied that if Commanding Officers could only see their way to working out the principle of employing their men at different trades, whilst keeping them efficient and smart as soldiers, and at the same time not unfairly working those who are not tradesmen or artisans, they would most readily give effect to it. My own experience of the subject has been very limited, but as it may serve to show some of the difficulties attending it, I venture to offer it to the Meeting. In 1866, when on service in Canada, we got up a Soldiers' Industrial Exhibition, which elicited considerable talent, and no little painstaking on the part of the Military in the western part of that dominion. Everything was duly prepared. I had read an address to the Major-General commanding there, praying him to open the Exhibition, and General Napier had just replied, when the whole thing was virtually broken up by a telegram reporting the crossing of our frontier by a large body of Fenians, and so causing the immediate dispersion of our men from the Exhibition at

Toronto. The following year the regiment under my command entered zealously on the cultivation of gardens at the same place. The men took a thorough interest in them, and, I must say, brought them to great perfection; but a sudden order sent us to Halifax, and we never reaped the fruits. In Nova Scotia, I received a communication from the authorities in this country desiring to be informed whether I considered it would be possible for the regiment to undertake most of the work in connection with the repair, &c., of barracks, usually done by the Royal Engineers. I replied at once that I should readily attempt to carry out the proposal, and that I entertained good hopes of success. The artisans of the Corps were organized, a skilful Non-Commissioned Officer placed over them, and a likely Officer of Industry duly off. Before authority was received for us to commence operations, the regiment was ordered to the West Indies, and thus ended, Mr. Chairman, the third attempt of the 47th Regiment to develope a system of Military labour. But, Sir, I have long felt an interest in the subject so ably handled by the lecturer to-night, and I rejoice that he has taken it up, for I am satisfied that there are no difficulties connected with so working the soldier that they may not be overcome.

The CHAIRMAN: It is my duty to invite Captain Webber, if he has anything to say in reply, to do so now.

Captain WEBBER: There is nothing, I think, left for me to say on the subject, because I find there have been no dissentients to any propositions that I have brought forward. Therefore, I only add that I am extremely happy that the few remarks which I have been led to put on paper have brought out such an interesting discussion.

The CHAIRMAN: I am sure I shall be doing my duty by thanking Captain Webber for the discussion he has originated, and for the valuable paper he has brought before us.

NOTE.—The following remarks are added at Dr. Stallard's request.—ED.

"At the risk of being considered Quixotic in my opinions, I should, nevertheless, be glad to be permitted to make one or two observations on the remarks of Lord Napier of Magdala on the necessity of directing the discipline of the soldier to the great object of his life, viz., actual war. I should be sorry to seem to differ with Lord Napier, when, perhaps, there would not be so much difference if we analyse the soldier's real requirements. What are they? I venture to think confidence in himself and his comrades, the result of health, good feeding, and the habit of moving and acting with others; fortitude, the result of a good knowledge of his weapons; and watchfulness, created and maintained by an intelligent appreciation of his position before the enemy, and of the enormous stake involved in an exact performance of his duty. Now, I venture to think that these qualifications are not cultivated by the practice of 'Sentry Go.' The man is deprived of his usual rest, he passes two hours out of three in a hot and often stifling guard-room; then he marches out, and is exposed to all sorts of weather, with nothing to keep his mind occupied, except the occasional visit of his Officer. How often do such men, if they have any intelligence, feel that they are in fact engaged on a disagreeable and useless duty? How often do they sigh for something to break the monotony of their march backwards and forwards, it may be, on some out-of-the-way rampart, where they are placed for the purpose of stopping the entrance or exit of some of their comrades, whom they have no heart to catch, because they may want to pass that way themselves another night. Where is the barrack that a soldier cannot break out of if he wishes, and where are the sentries that a comrade cannot pass? The gymnastic courts make them all good climbers; so that I venture to think that the men would be better in bed, that their attention would be better cultivated by doing honest work. I will back the watchfulness of an intelligent soldier, who has only done the "Sentry Go" a dozen times, against that of an old hand who has learned how to pass the hour on sentry with as little trouble as he can.

"Mr. Kinglake has some very strong remarks on the carelessness of the English sentries before Balaklava, and he attributes it to the habit of doing useless "Sentry Go's" at home. The men acquire the habit of inattention, because, as a rule, little

or no attention is required. The whole matter is regarded as routine, and the real question is, whether the time has not come when we may wisely substitute intelligence for it, not altogether, perhaps, but still to a considerable extent. Any thing, therefore, which improves the character of the soldier ought, in time of peace at least, to stand before mechanical routine; and I hold that regular habits and genuine hard work will prove the best foundation for a faithful performance of duty when the moment of action comes. The knowledge of his weapons and his drill of course stand first; but even with respect to the latter, it has often struck me as an useless and, to many men, a disgusting regulation, which requires that every man in the ranks, even if he has passed a dozen years in the Army, is obliged to go through his goose-step every year, as if he were a raw recruit, and this, notwithstanding that the man may have been temporarily promoted to the non-commissioned ranks. The fact is, that the soldier is too much treated as an ignorant child, and the complaint is continually made that he is so in reality. Whilst everything is done for him, even to the regulation of his smallest movements, he will be nothing else. If a mechanical machine is wanted, this is, of course, the right process, because routine discipline is the agent by which individuality is destroyed. But if we once recognise that individual self-reliance and intelligence are preferable, then we must be careful lest we give routine too high a place."

LECTURE.

Friday, January 21st, 1870.

Rear-Admiral SIR JOHN C. DALRYMPLE HAY, Bart., M.P., C.B., F.R.S., &c., in the Chair.

"WORKING HEAVY GUNS AND PROJECTILES."

By H. D. P. Cunningham, Esq., Major 3rd Hants Artillery Volunteers.

In the year 1861, when it appeared evident that a great revolution was about to take place, or, in fact, had commenced in gunnery, and that much larger cannon than had before been used, would certainly be adopted, I was urged by some influential naval friends to turn my attention to the production of means for working the future ponderous guns and projectiles.

I should here mention that I had already given much attention to the working of guns. In 1849 I was examined before the Ordnance Select Committee upon the subject of a plan which I had submitted to the Government for loading at the breech and for checking the recoil of a gun by the action of air in a tube placed between the slides, a description of which can be seen in the *Mechanics' Magazine* of July 21, 1849. Well, having made up my mind to take up the subject, I went into it very ardently, in fact giving up nearly the whole of my time and attention to it. After frequent attendance at experimental practice on board the "Excellent" with the heaviest guns then in use, I soon detected what would be required for the working of our future heavy guns, and after some months of close reflection, in the autumn of 1862 I had so far matured my schemes as to enable me to embody them in a Patent, bearing date 7th October, 1862, and which contains in a remarkable manner the mother-ideas of almost every method by which our modern heavy guns are now worked. I will distinguish these methods, and I will attach to each a short extract from the specification of my Patent.

First. The use of an endless chain for running guns in and out, with a provision for grasping the chain and releasing the carriage from it when the gun is fired.

ENDLESS CHAIN FOR RUNNING GUNS IN AND OUT.

Patent 7th October, 1862. 2710.

Page 2, *line* 13.—" The bands, ropes, or chains ('endless,' *page* 6, *line* 27) thus " revolving along the slide will have motion in two directions, viz., towards the centre " of the ship and towards the outside of the ship, and it is these two opposite " motions which I employ to run the gun in and out. This is effected by suitable " compressors being attached to the carriage, and arranged so as to compress or " grasp the chain, and thus the required motion is conveyed to the gun carriage, in " the direction taken by the chain or band or rope so grasped, either to run the gun " in or out."

The above further described in a similar manner at *page* 6, *line* 37.

2nd. The application of V-wheels and winches upon the ends of the slide to work with rope for the purpose of running guns in and out, and traversing them.

V-WHEEL SYSTEM OF RUNNING IN AND OUT AND TRAINING OR TRAVERSING.

Patent 7th October, 1862. 2710.

Running in and out.

Page 2, *line* 34.—" These windlasses or V-wheels on the end of the slide can also " be applied to any other service required in the working of the gun, and instead of " the compressor arrangement before described, may also be employed in running the " gun in and out by the action of ropes or tackles."

The above further described and illustrated at *page* 6, *line* 30, *figure* 5.

Training or Traversing.

Page 2, *line* 21.—" The next is to effect the horizontal training of the gun, and this " is accomplished as follows:—Train ropes or tackles are to be attached to the " ship's side or elsewhere, as may be desirable; these ropes are to be led through " snatches, fair leaders, or sheaves on the slide, at convenient positions for the rope " to be put upon the V-wheels or windlasses or winch barrels, attached to the spindle " before described, fixed to the aft end of gun slide. Now if the muzzle of the gun " be required to be trained to the left, the train rope or tackle on the right side of " the slide will be applied to the windlass or V-wheel on that side, and the effect will " be that the end of the slide will be drawn towards the right and the muzzle turned " to the left, &c."

Further described and illustrated *page* 6, *line* 30, *figure* 5.

3rd. The employment of overhead railways for facilitating the conveyance of the shot to the muzzle of the gun.

OVERHEAD SHOT RAILWAYS.

Patent 7th October, 1862.

Page 8, *line* 16.—" As regards broadside guns I facilitate the transport of the shot " to the muzzle of the gun as next explained. *Figure* 11 is a side view of a gun " run in ready for loading, AA is a traversing bar fitted at one end to turn on an axis, " &c.; upon this traversing bar, is a carriage fitted with rollers, and furnished with a " pulley at the lower part; through this pulley is a tackle which connects the car- " riage to the shot-holder, also furnished with a pulley as here represented. The shot- " holder E is on the deck below, to which it has descended through the scuttle to the " deck at F. By pulling on the tackle above, the shot can be elevated to the desired " level. The carriage is rolled outward on the bar as shown at D, the bar is then

"pulled round on the arc BB (*see fig.* 12) until the shot is brought to the muzzle of "the gun, when it is easily lifted out of the holder into the gun."

This was followed up by a subsequent Patent of Improvement, from which the following is an extract:—

OVERHEAD SHOT RAILWAYS, *continued.*

Patent 5th January, 1866. 43.

Page 1, *line* 15.—"The next part of my invention consists in improved means for "facilitating the transport or conveyance of the projectile and ammunition to the "muzzle of the gun, by means of overhead railways curved round the front or muzzle "of the gun, so as to enable a carriage having the projectile or ammunition suspended "from it to be carried round in a convenient position for the projectile or ammunition "to be put into the gun." * * *

Page 2, *line* 16.—"Overhead railways from various parts of the ship can be "arranged to be in correspondence with the curved way."

Page 4, *line* 34.—"The illustration here given refers to broadside guns, but the "curved overhead railway is equally applicable to guns in turrets."

4th. The adoption of grooved rollers or trucks and raised racers, to give increased security to the gun when being worked in a heavy sea.

RAISED RACERS AND GROOVED ROLLERS.

Patent 7th October, 1862.

Page 6, *line* 6.—"For the purpose of giving security to the slide, and to meet the "strains to which it may be subjected, the slide is supported and traverses on grooved "friction rollers, as seen at NN, *fig.* 1, which rollers traverse on raised circular plates, "as seen in *fig.* 3, at MMMM."

5th. The arrangement of shot and ammunition scuttles contiguous to the guns, so as to lessen the distance for conveying ammunition along the decks.

SHOT AND AMMUNITION SCUTTLES.

Patent 7th October, 1862.

Page 2, *line* 39.—"To increase the safety of working the powder, I have scuttles "at convenient positions with reference to the guns—these scuttles have closely "fitting shutters; there will be, say, two of these scuttles to each gun."

Page 3, *line* 12.—"As regards the service of shot and shell, I adopt similar "arrangements to those before described for the service of powder, and especially as "regards the supply of shot and shell from below."

Although these inventions chiefly referred to broadside guns, I also directed my attention to the working of heavy guns in turrets, believing that although the circular horizontal movement of guns had been obtained by all Captain Cowper Coles' admirable inventions, the moving of the guns in and out upon their slides, and controlling them when in motion, had to be provided for. In a paper which I had the honour of reading before this Institution on the 15th Feb. 1864, I described my plan for working turret guns, by applying steam direct to a cylinder placed between the slides; the gun-carriage being geared on to the end of the piston rod. By the movement of a valve-lever the gun

can thus be driven in and out, and I also proposed using the cylinders to check recoil. On referring to the diagram of that paper it will also be seen that I provided for the alteration of the level of the gun by raising and *lowering it in the carriage by screws at the trunnions.* I may mention by way of parenthesis, that I have been informed that the working of turret-guns by steam as thus proposed by me in my patent, has been adopted on board many vessels of the United States' Navy, and has been found satisfactory. My impression is very strong, that it is the proper way of working a heavy gun in a turret. At the time, I was much impressed with the belief that the future ponderous guns would require steam power to work them, and so in this comprehensive patent I provided for the application of steam-power to my various mechanical arrangements, and which could thus be worked by steam or otherwise.

Now I need not point out to those conversant with modern naval guns that all the means I have here described for working heavy guns, are in operation upon our guns.

The endless chain; the V-wheel rope system; overhead shot railways; the grooved rollers or trucks ("Hercules" gun carriage); ammunition scuttles, all these appear in the methods in use for working our heavy guns. It has been remarked to me, "Oh! anyone might have thought "of them; there is nothing new in these mechanical appliances." The same thing was often said to me before, with reference to my invention for reefing topsails of ships from the deck, yet it was clear that although anyone might have thought of doing this, so easy, so simple as it was *when done*, yet no one had thought of it. And so it clearly is with regard to my gun-inventions. No one had thought, or at any rate had published that thought, of running a gun in and out by the endless chain, with my simple provision for releasing the carriage from the chain when the gun was fired. No one had proposed to run guns in and out and traverse them by ropes over V-wheels fitted to winches on the ends of the slides until I proposed it, and so with my other inventions. Thus my first patent was followed up by many others containing inventions for working heavy guns, both in batteries and on board ship, and subsequently for handling the projectiles; amongst which may be chiefly noticed a plan for introducing the radius bar or flap into a cavity under the port sill (10th Feb. 1864, provisional specification). This plan has been used extensively. A large friction block compressor (10th Feb. 1864) was applied to the first 110 pr. Armstrong gun on board the "Excellent;" my chain traversing gear, &c.

I am, however, afraid that I have already occupied too much of your time upon this preliminary section of my paper; yet it was necessary to enter into this, as a large part of it forms the text to the matter to be hereafter treated of.

In the papers which I have before read to you, I have already described many of my plans which had been put into use. You will remember that I stated, that in the first instance I aimed at getting put into operation the most simple forms of my various inventions, from the belief that it was far better to accomplish, if possible, the desired end by simple means, and resort only to more complicated arrangements,

when the more simple ones failed. Well, in my last paper I described to you a most simple plan for "running in and out" by side chains, and also a plan for traversing by a "continuous chain," which I have subsequently denominated my "detached traversing gear," both which plans had then been in use some little time, and had certainly fulfilled all the conditions undertaken for them. I purpose using these old diagrams in order to refresh the memories of those who probably may have forgotten the subject, and to inform those who may not have been present at my lecture. The "running in and out gear" here shown then applied to a 12 ton gun on board the "Minotaur," continued to work that gun efficiently for a long time, and was eventually transferred to a 12 ton gun on board the "Excellent," where it continued in use altogether about two years and a-half. The traversing gear was at work on a 12 ton gun on board the "Minotaur" the last time I visited her, making upwards of four years wear from the date of its being first used. It was the original fitting, and I am sure that you will allow that the length of time in which it was in use, and that too without amendment or repair, was a satisfactory proof of its practical value. I cannot dismiss the subject of this traversing gear without expressing my conviction, that the merits of it have not been satisfactorily estimated. I am free to admit that the revolving of guns by a cogged-arc possesses more mechanical completeness than is obtained by my chain system; but I hold on the other hand, that there exists some very grave objections to that system. I remember once on visiting a target ship that had been recently fired at, being very much struck with the curious accumulation of *débris* that was upon the deck. I observed the same thing in the casemates of the Plymouth shield after it had been fired at. On the floor was a thick collection of broken pieces of iron, stone, &c.; and, again, in the turret of the "Royal Sovereign" after it had received the blows from the "Bellerophon" guns, were to be found sundry fragments of iron, &c. Now it is I dare say very difficult to imagine the state of the fighting-deck of an ironclad in action, but I believe the same condition will occur that I have alluded to. Fragments of iron, wood, &c., will be detached and fall upon the deck, and I believe these fragments falling upon and between the cogs of the cogged racer, will form serious embarrassments. It may be said, Oh! that is easy enough to clear; but in the heat and excitement of action, these things are not done so easily; and at a moment when some fine movement may be required of a gun, its powers of training are arrested. It must, moreover, be borne in mind that from the few number of guns now constituting the armament of a ship of war, the temporary disability of a gun would be more seriously felt than with a number of guns, as in the olden time. Another most serious consideration in regard to the system of traversing guns by a cogged-arc is the danger of the displacement of the centre or the pivot, by shot striking in the vicinity of the lower part of the port-sill. In the real model of a port at Shoeburyness fired at some time ago, it may be seen that the lower part of the port-sill has been evidently a favourite point of impact for the shot, and the pivot will be seen to be displaced by several inches. This existing in a gun traversed by a cogged-arc would not only upset the power of traversing,

but the gun would be rendered immovable by any means, until the traversing gear were disconnected. Now with my chain-gear these accidents are not likely to cause impediment. The pivot-bolt must be displaced a long distance before it would produce any serious effect, and the fragmentary deposits I have alluded to would certainly not affect the action of the traversing-chain, either in my detached gear or when the gear is placed upon the slide or platform, as in land-service guns. I feel very strongly indeed upon this point, and I only wish that it were in my power to put the matter to practical test. I wish that this experiment could be tried, viz., two ports of an ironclad to be prepared as nearly as possible representing the real thing. In one port, place a 12 ton gun fitted with what I will denominate the "service gear," that is, the cogged-traversing-arc, and endless-chain running-in-and-out-gear. The other port to have the same sized gun placed in or fitted on my system for running in and out and traversing. Then fire say 12 shots at each port under same conditions, four to be aimed at the lower part of the port-sill, two to be aimed to enter the port, two to be aimed close to the right side of the port, and two on the left, and two close to the upper part of the port, and then to observe the working condition of each gun. I am very sanguine what the result would be. I may add to the conditions, that each gun be allowed the spare fittings deemed to be necessary, and after the trial, such shift to be made as the nature of damage may require to render the gun serviceable, if damaged.

I will now proceed to tell you what I have done in working heavy guns and projectiles since the reading of my last paper.

I have shown that my simple plan of running in and out by side-chains, was transferred to a 12-ton gun on board the "Excellent," where it was still working, on Captain Hood's joining that ship. Not long afterwards, Captain Hood proposed to me to take the winches off the carriage and fix them on to the ends of the slides, in fact in the manner I have already described in the specification of my patent of 1862. This I carried out, I think, in a very nice way. I fitted standards to slip over the ends of the slides, as I now show you on this model, these standards carrying the winch-gear. I also fitted blocks to the train-bolts on the slide. A train-chain on each side was led from train-bolts on the deck through these blocks, and thus the gun was trained as well as run in, by the winches. The ability to run the gun in, out, and traverse it by this arrangement having been satisfactorily determined, I then proposed to Captain Hood, and obtained permission to apply, my V-wheel system to the gun, which was done. The result was that the gun could be run in by four men, and traversed by about the same number. The nip of the rope was so perfect that it required no effort to hold the end on, and again the rope delivered itself with perfect freedom.

Another highly satisfactory result was also ascertained as regards the wear of the rope, which was so little, that after 1,000 rounds, or rather after the gun had been run in 1,000 times, the rope was still serviceable.

Being anxious to prove still further the ability of my V-wheel system, by working a gun actually at sea, I applied to the Admiralty to fit a

12-ton gun on board the "Minotaur;" this having been allowed, I took in hand a 12-ton gun accordingly, providing it with every kind of application which I could devise to ensure control over the gun in a heavy sea; and in the course of my study of the subject, I designed the application of bollards upon the carriage, it being again one of those simple things that it might be said anyone might have thought of; and yet it was clear no one had done so. I look on these bollards as a very valuable application. Fig. 1 (Plate viii) is a side view, and Fig. 2 a ground view of the fittings of the "Minotaur's" carriage.

I will use the late lamented Admiral Warden's own words to show the perfect success of this means of working guns:—

RETURN to an Order of the Honourable the House of Commons, dated 29th July, 1868:—for

COPY "OF A REPORT from Rear-Admiral Warden, dated the 11th day of July, 1868, enclosing Letters from Rear-Admiral Ryder and the Commanding Officers of Her Majesty's Ships in the Channel Squadron, upon the subject of the respective Merits of the various Ships."

Extract from Admiral Warden's despatch of the 17th July, 1868.

"There are two gun-carriages and slides on board this ship, fitted with Cunningham's running-in-and-out-gear, one to the 12-ton gun, which has the training gear with fixed winches, and the other to the 6½-ton gun from the 'Excellent,' which has an adaptation of Cunningham's invention, with the addition of a gun-tackle purchase for training; and in point of fact the two are one and the same thing.

"The first mentioned is what Cunningham calls his V-wheel system, and the other is a mere copy, with slight modifications in the shape of the wheel and the position of the bollards.

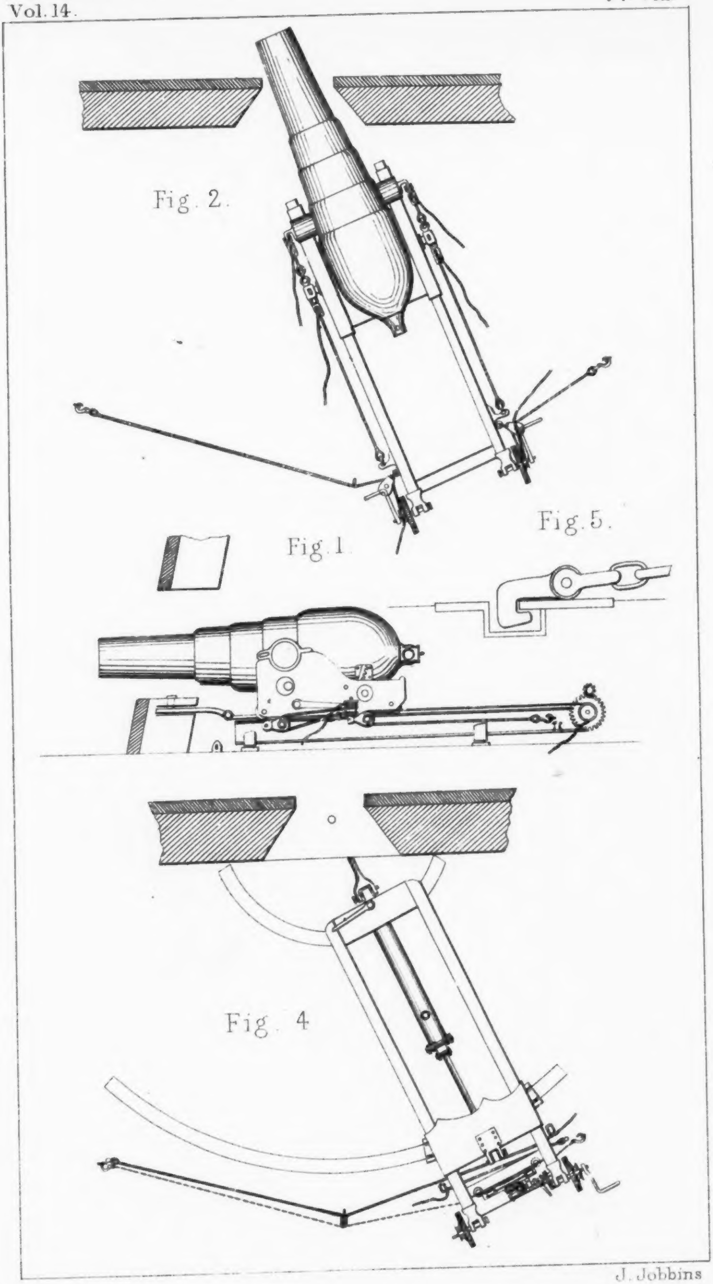
"They are, however, practically the same thing, the one from the 'Excellent' being the better fitted of the two, which is to be accounted for by the fact that the 12-ton gun was fitted at Mr. Cunningham's expense, and the other at the expense of the Government.

"The trials which have been made with this running-in-and-out-gear have been highly satisfactory; and I recommend that it be adopted at once throughout the Service for the 7 and 8-inch guns. Captain Goodenough approves of it so much that he is of opinion that it should be adopted also for the 9-inch gun; and I see no good reason for dissenting from that opinion.

"If the modification of Cunningham's plan, as emanating from the 'Excellent,' should be adopted, I wish to express my opinion that, in justice to Mr. Cunningham, it should always retain his name, and not be merged in the universal name of 'Service Running-in-and-Out-gear.' Simple justice, I think, demands this."

Here, then, it will be seen that a 12-ton gun was safely and securely worked by this very simple and inexpensive mechanical arrangement, scarcely costing £30. I may observe that the opinion of Admiral Warden and Captain Goodenough, as to the sufficiency of my V-wheel system to work 12-ton guns, has been practically acted upon by several foreign countries, many 12-ton guns having been fitted by Sir William Armstrong and Co. on this system.

I imagine the diagrams so completely describe the arrangement as



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scarcely to need specification. In Fig. 1 will be seen that the running-out rope is taken round the bollard, the end is supposed to be held taut, and eased carefully off as the gun is run in.

The large cog-wheels of winch are furnished on the inside with a cogged rim and catch, or paul, so that outward re-action is provided for; whilst with careful attention to the rope over the bollard, it is almost impossible for the gun to break away. Fig. 2 illustrates the traversing arrangement. It will here be seen that the running-in ropes have been taken off the V-wheel, and train ropes led through blocks hooked to the train-bolt on the slide put over the V-wheel. It can be easily understood that if the train-rope is hove in on one side and slacked out on the other, the gun is trained round in that direction. I have so much confidence in the power of my V-wheel system, that I have undertaken to the Admiralty to work an 18-ton gun on the system. The train-rope on the left side of the gun will be seen to be apparently fouled over a bolt; this is a purposed arrangement. If considered, it will be understood, that the rope in its present position is at a much more favourable angle for traversing the gun than were it led straight to the traversing-bolt. The bolt which thus keeps the rope back I denominate the snatch-bolt; a full-sized figure of it is shown in Fig. 3 (Plate x). The rope is simply laid over it, and is as easily released; in fact, as the gun revolves round, the rope releases itself on one side, and the rope on the other side lays itself over the snatch-bolt. These snatch-bolts will be frequently referred to in subsequent descriptions. They perform an important function in my traversing systems.

Believing that a combination of my V-wheel system of running in and out might be advantageously combined with my rear-chain traversing system so successfully applied to land service guns, I carried out an arrangement of this description for a naval gun; one of the side winches being used for traversing, by connecting gear to the central works. Fig. 4 represents a ground plan of such a gun-carriage fittings, and I further illustrate it by this model. My impression is very strong that this is a most complete arrangement for naval guns; it is simple and inexpensive, and the mechanical action is quite sufficient to obtain necessary precision in training. It may not be so rigidly complete, mechanically, as the cogged-arc, but practically it is quite equal to it, without many of its objections.

It will be seen that I apply bollards upon the slide and preventer train ropes for bad weather. These ropes I lead under the slide; by careful attention to these I believe most thorough control will be had over the gun. I wish to draw your attention to the fact, that the means I employ for commanding the gun in all its movements are those familiar to the seamen; I place importance in this, for I know that this is appreciated by the seamen on board the "Minotaur." In the illustration, the ends of the traversing ropes or chains are represented as hooked to eye-bolts; I have, however, provided what I believe to be better than this; instead of an eye-bolt I sink a plate into the deck with a slot in it, and into this is inserted a hook of peculiar shape (Plate viii, fig. 5). A cover is provided for covering the slot when the train-rope is not used. By this arrangement the deck is kept free from eye-bolts projecting upon

it. Fig. 5 represents this deck stopper; I have already applied this very satisfactorily.

In concluding this description of my V-wheel system, I have to observe that all the 6½-inch guns in our naval service are now worked by it. Soon after I had completed the fittings of the "Excellent's" gun, a person, I believe from Woolwich, was sent to that ship, to take plans of my fittings, and from those plans the present winches were made. I must mention that when I first introduced the subject of my V-wheel system, I proposed to use a twisted groove, and the first model I produced on board the "Excellent" was of this kind. I, however, saw objections to this form of groove. I believed that it would wear the rope considerably, and that the rope would not deliver well, and so I arranged my present wheel with a straight groove. When I found that the Admiralty had adopted this, what I considered imperfect form of wheel, I thought it my duty to write to them on the subject, pointing out that I was sure they had committed an error. The result of my letter was an order to Captain Goodenough to report on the respective merits of the two forms of wheel. I have not seen the official letter on the subject, but Captain Goodenough most kindly wrote to me a note upon the result of the competition, and as there is much public interest attached to the matter, I am sure that Officer would not object to my using his own words:—

Extract from a Letter from Captain Goodenough, Commanding Her Majesty's Ship "Minotaur."

"H.M.S. 'Minotaur,'
"Off Cape Finisterre,
"December 9th, 1868.

"I have just sent in my report on the V and S Rope Wheels. I have said that your gear has been in use eight months, and that of the War Department (copied from the Cunningham's) six months; that in that time the two guns to which the gear has been fitted have had equal work; the 7-inch gun fitted by the War Department having been drilled oftener. But that while the rope is same size, yours has drawn a 9-inch 12-ton gun, and the other a 7-inch 6½-ton gun. At the end of that time, the War Department gear has completely worn out its rope by destroying the yarns (and it has been removed), while the rope on your gear, though stretched and reduced in size, is unbroken, and remains in use. Thus your gear has the victory, though tried at a disadvantage. The rope never slips in either, but it becomes jammed in War Department gear, and costs trouble to extricate.

(Signed) "JAMES E. GOODENOUGH."

In the paper read by me here in February, 1866, I described my proposed system of overhead circular shot-railways. Shortly after that lecture, my system was applied by me to one of the guns of the "Minotaur," and the official report of Captain Goodenough I now give:—

Extract from Captain Goodenough's Despatch of the 10th July, 1868.

"An overhead rail for loading 9-inch guns fitted by Mr. Cunningham, has now had a year's trial. It could not be fitted entirely as was wished, on account of the curve of the upper-deck beams. Still it is a very excellent plan, and were it not for

Fig. 6

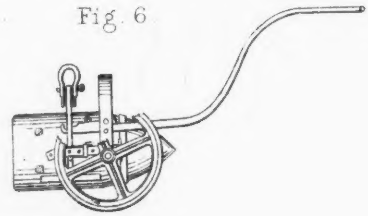


Fig. 7.

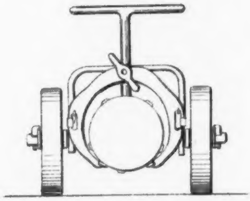


Fig. 10.

Fig. 9

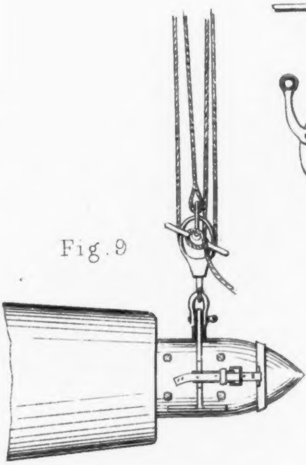


Fig. 8

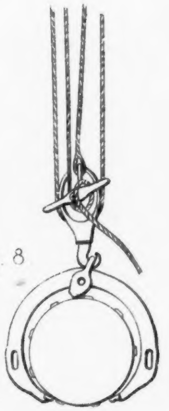


Fig. 11.

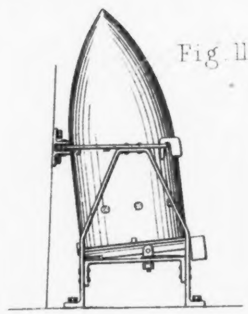
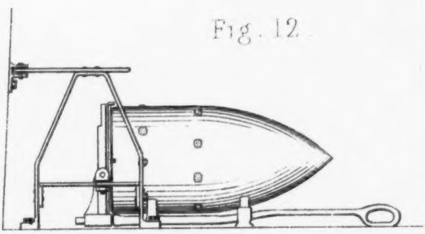


Fig. 12.



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the reasons stated above, I should prefer it very much indeed to the ordinary loading whip. I recommend it being fitted in any ship where the height of the beams admits."

[Ordered by the House of Commons to be printed, 31st July, 1868.]

Since the fitting of this gun. "Overhead Shot-Railways" have been fitted extensively on board the "Monarch," and I understand have been ordered to be applied to all new ships. The form of rail fitted by the Dockyard authorities differs in constructive detail from that of mine; but the original design of using these assistants I must claim as mine.

I must now call your attention to diagrams, Figs. 6, 7, 8, 9, 10, which illustrate the provisions I have made for assisting in the service of the projectiles. They consist of a carriage or truck for picking up and transporting the shot, and lifts or slings for lifting it, conveying it to, and putting it into the guns; also shot racks (Figs. 11, 12), to facilitate the taking down and putting up of heavy projectiles. Fig. 11 represents a rack lately tried on board the "Monarch." It will be seen by the diagrams—and I also illustrate my subject by the implements themselves—that the sling consists of a hoop, formed on the edgeways, with a section of the circle removed at the bottom (see Fig. 8); this admits the hoop being placed over and along the projectile. A stopper hoop and strap appear on the projectile in Fig. 9, the action of which is to regulate and preserve the proper position of the sling upon the projectile; these straps pass through long slots in the sling, and these slots also serve to receive the lever-like ends of the carriage for lifting the shot. This is done by simply wheeling the carriage over the projectile, and inserting the ends of the projecting part into the long slots in the sling, all the parts of which are so constructed as to accommodate themselves to their several actions; and with a small amount of practice a projectile can be picked up almost in the dark. The straps alluded to keep the sling in its proper position when the carriage is wheeled over to pick up the shot. It is found in practice better to keep the carriage in echelon, as it occupies less space, and comes to its work better. Fig. 6 represents a 9-inch shot just picked up. The shackle on the top is for the purpose of suspending the shot. It will be seen, on reference to Fig. 8, that when the shot is suspended, the elongated part of the shackle presses upon the shot, and gives a great nip to it. It is almost impossible for it to release itself. Fig. 9 represents the muzzle of a 9-inch gun with the projectile on the eve of insertion into the bore. A great advantage exists in being able easily to adjust the studs to the grooves of the rifling. Nothing can exceed the facility with which the projectile can be put into the bore of the gun by my system. The experimental detachment of gunners at Shoeburyness are now so thoroughly up in using my shot slings, through the intelligent instruction of Captain Alderson, that it is really very pretty to see the smooth, easy manner in which they pick up a 600-pr. shot and put it into the gun. Fig. 10 represents a handbearer or lift, used at Gilkicker Fort for the 12-ton guns, and which has proved itself far superior to the service bearer, both in weight, ease of lifting the shot, and time of putting it into the gun. It also extracts the shot quicker than the service bearers, and is lighter,

and 100 per cent. cheaper. Figs. 11, 12 represent my shot rack, which, it will be seen, is constructed with a bottom, which can be canted, and a lever fitted with crutches or saddles is arranged to fit into a socket in the movable bottom, when it is required to take a shot out of the rack; the lever being shipped, the shot is tripped up and eased down by the lever. The crutches upon this lever are so arranged as to allow the shot-sling to be passed over the projectile; the shot-carriage is then wheeled over it, when it is lifted and conveyed away with the greatest ease. I have much pleasure in illustrating this practically by the shot rack, carriage and slings for a 600-pounder shot, which are in the Institution. These forms of shot rack, carriage, &c., were lately tried on board the "Monarch," against the existing means on board for the service of the shot, and the result was very remarkable. Two 600-pounder projectiles were taken from these racks upon equal conditions, and conveyed to the point for lifting into the turrets. Two men on my system conveyed the shot to the required point in 15 secs. Eight men, on the other hand, took 1 min. and 15 secs. to perform the same operation. A great recommendation in my system is that the sling, which forms as it were part of the carriage, also serves to convey the projectile to, and puts it into, the gun, as before referred to. Fig. 9 represents a projectile being thus put into the gun. Before the "Monarch" left on her present melancholy voyage,* I had the pleasure of supplying her with shot carriages and slings complete for one of her turrets.†

And now I arrive at a very interesting section of my paper, the subject of checking recoil. As I have before stated, so far back as 1849, this subject had occupied my attention, and in that year I was examined before the Ordnance Select Committee upon a plan for checking recoil by the action of air in a tube or cylinder between the slides.

Having in the frequent experimental practice of guns observed the irregularity of action of the plate compressors, I again took up the subject of my air compressor, and on the 12th June, 1867, forwarded to the Admiralty drawings of a design for an air-compressor, or recoil stopper, in which plan I proposed to use the pressure of the atmosphere, combined with the resistance of compressed air; this design is represented in Fig. 4. It will be seen that between the slides is placed a tube or cylinder; in this is fitted a piston and rod, the end of the rod being geared on to the after end of the gun carriage. A guide is provided to secure the end of the piston-rod working true, and which also serves to tie it down securely, and guard against flexion. The outer end of the tube is closed, and provided with a valve worked by a handle, which will be readily discerned in the diagram. The inner end of the tube is also closed, the piston-rod working in a stuffing-box. At say two feet from the inner end of the tube is an air port, which will be readily recognized. The action of this arrangement is, that when the gun is run out ready for firing, the valve at the outer end is

* She conveyed the remains of the late Mr. Peabody to America.

† These shot appliances have given such satisfaction, that on the return of the "Monarch" to Portsmouth, Captain Commerell applied to have Cunningham's shot carriages and slings supplied for the foremost turret.

closed; on the gun moving in by the recoil, it of course carries the piston with it, and the result is, that a vacuum is formed in the inner part of the tube, and an atmospheric resistance created on the other side of the piston; this is intensified by the air-port being so small as to retard the free escape of the column of air violently propelled along by the quickly travelling piston, and which upon passing the air-port, now enters into the part of the tube where the air cannot escape at all, and which thus forms a highly elastic buffer, finally subduing the force of the recoil, and reducing the gun to a state of rest.

Another action is now obtained. On the piston passing the air-port, the vacuum in the outer end of the tube is destroyed, and a column of air now fills the tube, preventing the return of the piston, and so retaining the gun in for loading. When ready for running out, or up, the valve is opened, and the piston is then left free to pass down. By careful attendance on this valve, the gun can be controlled in running out in a sea way, as by shutting off the valve a cushion of compressed air is formed on which to receive the descending gun.

I have no doubt that with the help of the diagram you will have been able to follow me in my description, and which I will now supplement by showing you the actual working of my invention by these models.

I had intended to confine myself in this paper to the description of those of my inventions actually in use. I cannot say that the plan I have just described is in use in the form brought before you; but any one familiar with the subject cannot, I am sure, fail to recognise a close affinity between my invention and that known as the water-buffer. The action is certainly identical. In the water-buffer, as it is called, air and water are used, instead of air alone, the wire drawing action is obtained by holes in the piston, instead of the air-port in my tube. Until actual experiment has proved clearly and distinctly that my principle is defective, I must hold to the conviction that my form of checking the recoil by the elastic medium of air is the right one, and I believe that will be the future compressor.

Up to this stage of my paper I have been treating only of naval guns, I will now pass on to land service guns.

In the year 1866 I was invited to take in hand the traversing of a 600-pounder gun, which was to be sent to Southsea for the purpose. I did take the matter in hand; I had determined that for land service battery guns, or guns in casemates, my rear traversing arrangement was the best, and accordingly I fitted this gun on that system. The gun was originally mounted on the floor that had been laid for the Horsfall gun. I allude to this as it made the trial of my gear more severe, as the gun was very close to the water, and in very heavy weather the spray washed over the gun. The success of my invention was very remarkable. I traversed the gun easily by means of one man; indeed a boy of 10 years old has done it. A man-of-war steam-vessel having been sent out to steam backwards and forwards, in order to ascertain the power of following a ship under weigh, it was found that one man could easily follow the vessel going at full speed at 400 yards, and with a large overplus of speed on the part of the gun. A striking circum-

stance connected with the fitting of the gun was, that the gun was fitted in position, and indeed in a few hours.

Fig. 13 represents this gun in its new position, inside the new battery at Southsea, where, together with its former more trying position near the water, it has been now upwards of three years, and my traversing gear is in perfect working condition. The gun is fitted to traverse 90 degrees, which can be done by two men in 90 seconds. It is a long distance to traverse, being 26 feet in the rear. It was in fitting this gun that the necessity for and use of the snatch-bolt I have alluded to, occurred. I found that when the gun was trained extreme, the chord of the circle described by the chain was very great, and resulted in the chain being very slack, and assuming an unfavourable direction. Accident showed me that by applying bolts of the shape of Fig. 3, the chain would lay itself over those bolts and again take itself off, and so the chain would be kept back, as it were describing a series of small chords of the circle instead of one large one, with the objections before alluded to. The action of these snatch-bolts is perfect; of course any number can be applied, and the chain preserved tight to any extent; but practically the three which appears in the drawing are found to be sufficient. And now I will point out how admirably adapted this simple system of traversing is to guns in batteries mounted on raised racers and with grooved rollers, without fixed pivots. In the first place it is impossible to have the grooves to fit quite tight, consequently there is some play, and the result of this is, the gun in revolving does not go truly round upon an axis, sometimes the rear gains upon the fore, and then when it clears there may be a start forward at the other end. With all this, then, it would be impossible to traverse a gun so mounted by cogged-arcs, the machinery connected with which must work radially true, and with the greatest precision; a requirement which does not exist with my gear. Again, I have alluded to the débris which collects on the floor of a battery in action, and of course in an open battery this would be very great in consequence of the earth from the parapets; by all this the cogs of a ratchet-arc would soon be rendered useless, indeed the arc would probably be covered over. This, however, would not affect my traversing chain, which would be efficient, even if the floor of the battery were covered a foot deep with earth or débris.

I cannot resist the temptation of inserting an amusing and yet striking anecdote connected with this gun. The summer before last, the Volunteer Artillery Corps to which I belong was under inspection in gun practice at Southsea. Before proceeding to Lumps Fort, Colonel Connell, commanding the 12th Brigade of Royal Artillery, who was the Inspecting Officer, expressed a wish to see the working of my traversing gear on the 600-pounder, in Southsea New Battery. Nothing could be more satisfactory than the exercise was, and as an extreme proof I traversed the gun with one hand only. On the inspection commencing I had to fire a round at the target, and as I arrived late in the fort, the gun that fell to my lot was an old 32-pounder, mounted on a ship carriage, and trained of course in the antique manner by handspikes. The change from the beautifully precise training of the huge 23-ton gun to this wretched little piece was beyond anything striking and ridiculous.

Fig. 13.

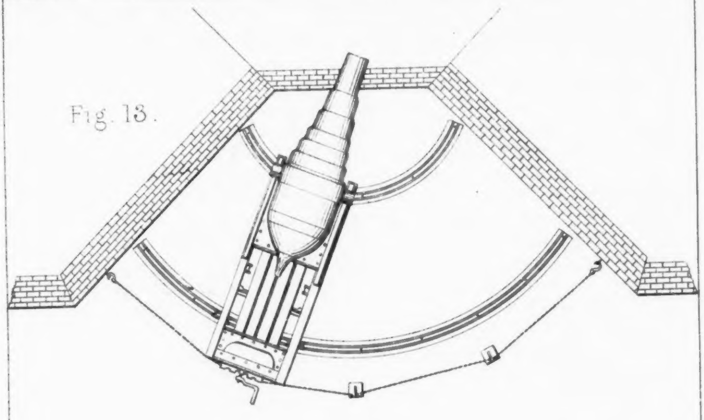

Fig. 14.

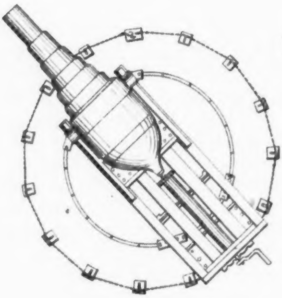

Fig. 15

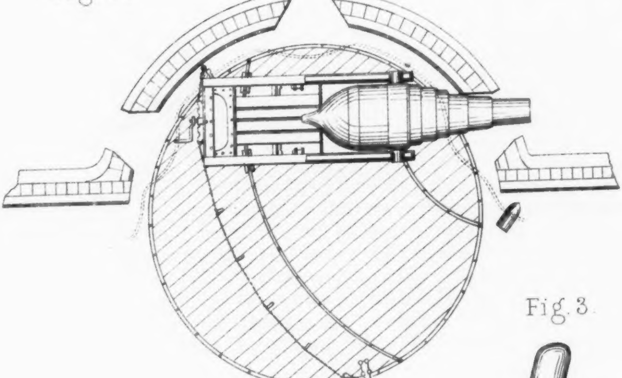

Fig. 3.

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However, I was obliged to fire my round. Sometimes the gun was hove too far right; the next spasmodic action of the levers took it too far left; then the bumping of the gun threw the elevation out in some way, and at last, as my time was up, I had to fire anyhow, trusting to chance only that the shot would go pretty near the target, which, as luck would have it, it happened to do.

In 1866 I received directions to fit my traversing gear to a 600-pounder, mounted on Colonel Inglis's turntable and fixed turret, at Shoeburyness. I was also directed to fit up that turret with my overhead shot railway, and my other arrangements for facilitating the service of the projectiles. Diagram Fig. 15 represents this gun. The arrangement of the shot railway is indicated by the dotted line. It will be observed that it is arranged to sweep round the gun favourably to the different positions assumed by the gun in training. I supplied this gun with shot carriage and slings, very similar to those already described. The improvement in loading this gun from the adoption of my plan was very great. Before this, the labour and time in getting the projectile to and putting it into the gun, were excessive, and the length of time a number of men were collected about the muzzle, getting the shot into the bore, exposed them much to shot entering the port. With my arrangements, two men can bring up the projectile, hoist it up, convey it by the railway to the muzzle of the gun, and put it into the bore. In experimental practice, a round was fired in 2½ minutes. I consider I did great service in the provisions I prepared for this gun. The traversing gear is similar to that on the Southsea gun; the ends of the traversing chain, it will be seen, are taken out to outriggers. I have been present at Shoeburyness, with a good deal of experimental practice with this gun, or rather guns, mounted on that carriage. I have been present altogether at about 100 rounds, and my traversing gear has stood well, and is now in perfect order.

And now I come to another interesting form of application of my system of traversing. The very successful self-action of the snatch-bolts which I have before described to you, led me to believe that an almost all-round-traverse might be obtained, and accordingly I undertook to fit a 600-pounder or 25-ton central pivot gun. This gun is represented in diagram Fig. 14. It will be seen that the snatch-bolts describe a circle beginning from the bolts or holdfasts of the ends of the chain. Thus the gun can be traversed round about 350°. This gun has also had a considerable amount of practice, and my traversing gear has stood well, and is in good working order. This gun necessarily stands high; it is intended, I believe, for a redoubt at Malta. The shot is hoisted up to the muzzle by a crane fixed on the gun; and my shot-sling is used for lifting the shot and putting it into the gun.

About a year ago I fitted two of the 12-ton guns, part of the future armament of the new Gilkicker Fort, with my traversing gear. Time has not allowed me to prepare a diagram of these guns, and I regret it, as the arrangement is very neat and satisfactory. Before I fitted these guns it was found that they could not be trained extreme by the train-tackles. The space occupied by the blocks, hooks, &c., would not permit the guns to be trained extreme, and it took ten men, who were

entirely exposed to shot entering the embrasure, to traverse the gun. When fitted with my gear, the guns were able to be trained to their extreme points, and by two men only.

I may mention that so far back as the 29th January, 1868, I received the following official intimation that my traversing-gear had been ordered by the Secretary of State for War to be adopted for all "land service guns of 12 tons and upwards," and therefore I may reasonably conclude that I shall ere long have the pleasure of seeing my system adopted upon all the fine guns with which the new fortifications about our coasts are being equipped.

"*Copy.* Minute 24—152. 2530. 2.

"Ordnance Select Committee,
"Royal Arsenal, Woolwich,
"29/1, 1868.

"Sir,

"The Secretary of State for War having, on the recommendation of the Ordnance Select Committee, approved of the adoption of your training-gear for land service guns of 12 tons and upwards, I am directed by the President to inform you, that as it is necessary to seal a pattern of this training gear to guide future supplies, a demand has been put forward, through the Principal Superintendent of Stores, Woolwich, for a specimen of the gear in question complete, for a 12-ton gun platform; and I am to request that on receipt of the order to supply, you will be good enough to prepare the same, with all improvements suggested by recent experience.

"I have the honour to be, &c.,
(Signed) "J. Heyman,
"Major and Secretary."

"H. Cunningham, Esq.,
"Bury House, near Gosport."

The imperishable nature of my gear renders it peculiarly well adapted for forts and batteries. However dry the storehouses in brick or stone buildings may be, still the deterioration of rope kept in vaulted stores is very remarkable. I was present at Gilkicker Fort, when three tackles were destroyed in one morning's exercise, and these apparently were not old stores. Only conceive, then, what a disastrous state of things such a failure of stores in the emergency of action would be. Now the fittings of my gear are almost imperishable. The chain is galvanised, so that corrosion cannot take place, and so a gun once fitted, will remain serviceable for a hundred years. I have already alluded to the fact of my gear being capable of being fitted to a gun in position, without the necessity of removing the platform to a factory. The guns at Gilkicker—indeed all the guns I have yet applied my system to, were thus fitted in position. I consider this a great advantage, as it admits of my gear being sent abroad, and applied to guns at a small expense, and without involving difficulties that might otherwise be created, were an amount of factory work obliged to be entered into. I would also again call attention to the striking fact of *one man being sufficient to lay a gun* so large as a 600-pounder, and that man completely under cover of the gun. This, together with the facility which my shot-appliances afford for rapidly putting the shot into the gun with few men, reduces the exposure of men about the gun to

a minimum, and removes much of the objection to mounting heavy guns in the ordinary manner in casemates and open batteries.

And now, Sir, I believe that I have exhausted my subject, with the exception of one remark, and that is, to call your particular attention to the simplicity which I have endeavoured to adhere to, in all my inventions for working heavy guns and projectiles. It only remains for me to thank you and my audience for the kind attention which you have given me, and thus to conclude the reading of my paper.

Evening Meeting.

Monday, 7th February, 1870.

H. F. DOWNES, Esq., in the Chair.

NAME OF MEMBER who joined the Institution between the 31st January and the 7th February, 1870.

ANNUAL.

Hobson, Frederick T., Capt. 3rd Regt.

STEENSTRÜP'S CONICAL SCREW AND BREECH-LOADING CANNON.

By Peter Jensen, Engineer and Patent Agent.

The principal aims sought to be attained in modern ordnance are, "strength of construction" and "facility for quick shooting." The first is obtained by composing or building-up the ordnance; the second by breech-loading mechanism. Built-up cannon consist of an inner part or core of steel or iron, whereupon coils are shrunk.

It is of course of importance to form the greatest cohesion, as well between core and coils as between the coils themselves; but looking at the best modern examples of built-up guns, it will be observed that, were it not for the friction or cohesion between core and coils, there would be no cohesion at all, for the coils are not mutually joined, in fact, often have spaces of $\frac{1}{16}$th of an inch between them after contraction and cooling; and the annular spaces thus formed round the core must always produce interruptions, which, however useful for the vibration, directly and seriously impair the strength. Such a construction is shown at *a*, in Fig. 1 (Plate xi). Could the coils be joined by screwing them together, by being formed as cylindrical screws, as shown at *b*, a greater cohesion, as in the direction of the axis of the cannon, would be attained, and also a somewhat greater transverse strength; but as the coil *c* must be shrunk on in a hot state, and while the coil *d* is cold, the expanded screw-threads of the hot coil *c* would not fit the cold threads on coil *d*, and their junction would not be so sure and exact as is desirable, while the transverse strength would be increased but

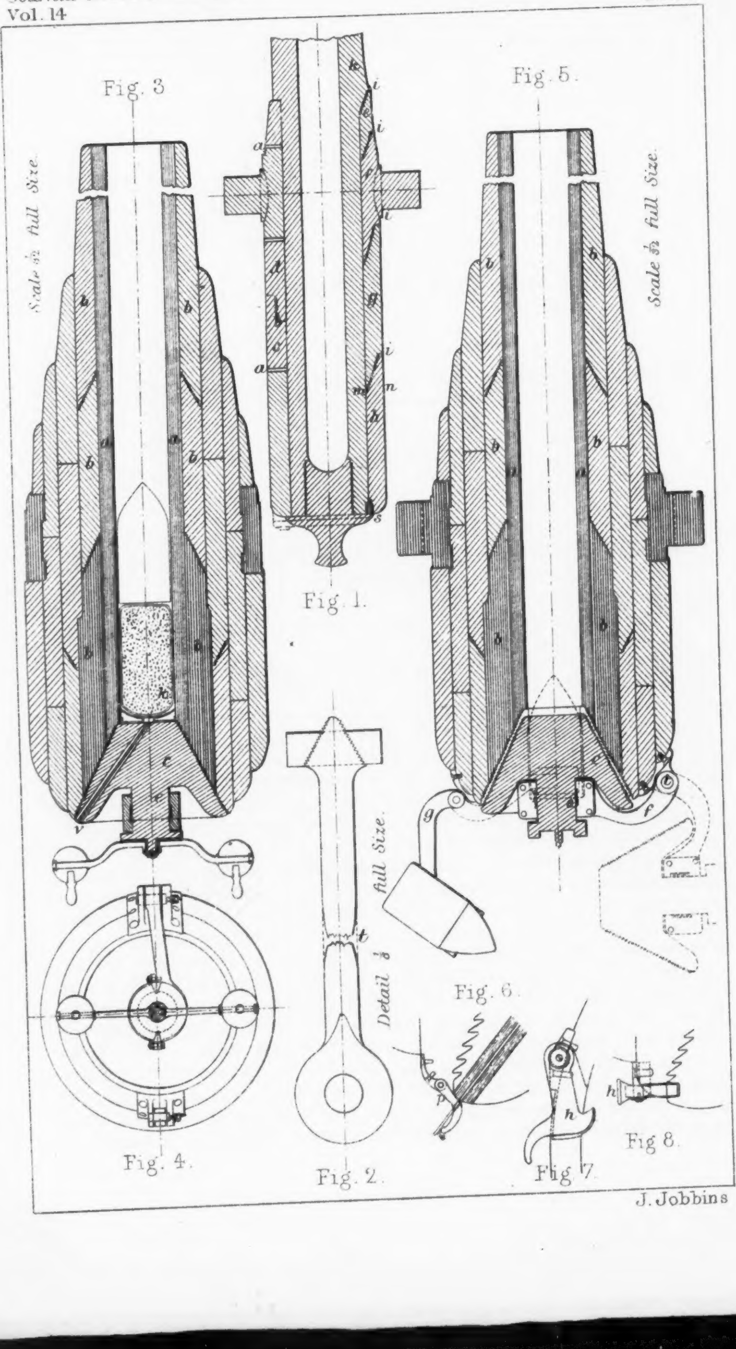
Fig. 3
Scale ½ full Size.
Fig. 1.
Fig. 5.
Scale ½ full Size.
Detail ⅛ full Size.
Fig. 6.
Fig. 4.
Fig. 2.
Fig. 7
Fig 8.

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50 per cent. The inventor bearing this in mind, has therefore contrived a stronger means of junction by a conical screw, which he, as will be shown, also applies to the closing of the breech. At present we will point out how the principle is applied to the junction of the coil *e* (Fig. 1) to the core *k*, the coil *f* to *e*, the coil *g* to the coil *f*, and the coil *h* to the coil *g*.

As the conical-screw by reason of its nature, even with many threads, takes into the threads of, and gets into perfect contact with, its nut, after only say one and a-half turns, it will be seen that the heating and consequent expansion of the nut does not impede the complete junction of the screw and nut.

The following points may here be observed:—

1st. That the junction at *i i i i* becomes as perfect as possible.

2nd. That nearly the full transverse strength of the coil over the core from *m* to *n*, is obtained in contradistinction to what takes place at *a*; and that the vibration in the core is transferred to a dense, strong, and compact mass.

3rd. That the coils during the cooling and consequent contraction, pull the core together exactly in the right direction, against the influence of the powder-gas, while the contraction of the loose or unscrewed coils may take place in the very opposite, and consequently in a wrong or deleterious, direction.

If a stop-ring now be applied at *s*, then it will be seen that a longitudinally very strong junction of the core is obtained, and a very strong gun produced.

The turning and cutting of the conical screw offers no practical difficulties whatever.

Though it is a very easy matter to calculate the strength of such a conical screw by taking the collective areas at the base of the thread, the inventor had a screw made, as shown in Fig. 2. With an area of 4½ square inches, exposed to a shearing strain, it withstood a force of 113,000 lbs., or more than 50 tons, without impairing the threads; with this force the bolt was torn asunder at *t*, but the nut was unscrewed with ease by hand, and its position, as marked by notches, had not altered.

The resistance of the screw against blows was next tried. It was put in the nut loose (without being screwed home), the nut was laid on an iron ring, and several powerful blows with a 100-pound hammer were struck on the protruding end of the screw, which in consequence got flattened as shown; the upper thread was even compressed, while all the threads in the nut were unimpaired, and the nut could be unscrewed by hand.

By calculation it is found, that the sectional area exposed to shearing strain in a coil-screw becomes so large that it about coincides with the limit of elasticity of the coil itself, and that consequently a corresponding amount of strength is gained in the longitudinal axis of the cannon.

The inventor considered these experiments as practical demonstrations of the strength and cohesion of the cone-screw; he then constructed a cannon in which the breech was closed by a conical-screw.

The drawings (Figs. 3, 4, and 5), show a 10½-inch breech-loading cannon of his construction, in half natural size. The model shows a 6½-inch cannon in one-fourth natural size; *a a* is the steel core of the cannon, *b b* the coils direct on the same, and joined by conical screws, and *c* is the conical screw closing the breech. This closing-piece rests with its neck or hind part, *e*, in the boss of a lever, *f*, movable round a fulcrum. The neck and boss fit each other, and form screw and nut of a pitch corresponding to the cone-screw, so that on turning the closing-piece one way or the other in the boss, the cone-screw may move concentrically and exactly in its nut, formed by the end or breech of the cannon.

When the closing-piece is turned one and a-half turns back, the cone-screw threads are out of contact with each other, and the lever *f*, along with the breech-screw, can be swung to one side, leaving the cannon open for loading. The projectile, which in the meantime has been placed in a cradle, on a lever, *g*, attached by a fulcrum-pin to the opposite side of the rear end of the cannon, can now with ease be inserted into the cannon by swinging the lever and cradle round, and after that, the powder-charge is inserted in a similar way; the cradle, with projectile or charge being just opposite the breech end, when its arm is swung home and stops against the breech. The breech screw is then swung in, and is then likewise in its proper position, without the cone-screw or nut being in contact before being screwed in.

The rear end, *k*, of the cartridge has a brass disc, with a collar and tightening disc of cardboard material, in the usual way, so that no powder-gas can escape into the threads of the breech-screw.

It must be particularly noticed that the construction or form of the screw threads, viz., with perpendicular sides where exposed to pressure, prevents any wedging or jamming against the threads in the breech; if the threads were the shape of an equilateral triangle, the case would of course be entirely different, and a very strong jamming action might be produced; as the now usual and approved method of preventing escape of powder-gas, as above described, will prevent any accumulation of dirt in the screw-threads, the breach-screw may in consequence be screwed home quite tightly, the same as is now done in the French breech-loading cannon; and it may at all times be screwed in or out with ease. The cradle on the lever, *g*, has got rifle grooves, corresponding with those in the cannon, if rifled, and the projectile and the cartridge will consequently always come in their right position in the cannon by the assistance of a short gauge rod.

The touch-hole, *v*, which is situated in the breech-screw, terminates at the centre of the cannon, so that central firing may be used, the brass plate on the cartridge having a central hole for the purpose. When the breech-screw is quite unscrewed, the touch-hole points downwards, and to prevent the insertion of the percussion-tube before the screw is quite home, a small, self-acting catch *p* (Fig. 6) is attached to the cannon, and has a hole through which the percussion-tube can only be inserted when the breech-screw is in that position.

The fulcrum pin, *t*, which carries the lever for the breech-screw has a small set or regulating screw for setting it up as it wears, thus always keeping the breech-screw central with the cannon.

The form of the breech closing-piece may be, as shown on the drawing, approaching the shape of the French system by Treuille de Beaulieu, or as shown on the model. The elevation mechanism may be of various constructions, for instance by rack and pinion. The closing-piece may be screwed into the breech by means of a double-handed lever, as shown by Figs. 3 and 4, or by a hand-spike or tommy, as on the model; and from experiments made with weights, as large as the closing-piece, it was found that one man was sufficient for executing the whole loading process and for firing a $10\frac{1}{2}$-inch cannon when the projectile was put in its cradle.

To make sure that the closing-screw should not unscrew during the discharge (which the form of thread, it is thought, will prevent) a stop *h* (Figs. 7 and 8) may be added; but experiments made, seem fully to show the uselessness of such an arrangement. It will be clearly observed that the threads of the breech-screw fit into the core of the breech-piece and the outer coil, whereby a closer junction of the component parts of the cannon is established, and if the breech-piece be made the same as at Woolwich Arsenal, the strength will be increased. Against the possibility of dirt getting into the screw-threads, thereby causing a greater friction, there is provided a hole in the rear of the cannon, for admitting a tommy or rod; by inserting this and moving it a little, the screw is loosened immediately, as will be observed in the model.

On comparing the sections of the thread exposed to shearing strain in this conical breech-screw, with those in Sir William Armstrong's breech-loading gun, and with those in the French system (Treuille de Beaulieu's), where half the thread is cut away, it will be found that this cone-screw is quite as strong as the one of Sir William Armstrong's, and double that of the French breech-loading cannon. Looking at the few parts this breech-loading mechanism consists of, the ease with which it can be worked, and the quickness with which the loading and firing is done, it is clear that at least double the number of discharges can be obtained in comparison with a muzzle-loader. The other advantages appertaining to breech-loaders in general, compared with muzzle-loaders, are too well known to need any enumeration here. It may be added that in the author's opinion no system offers such great advantages for breech-loading, if a thorough efficient one could be found, as that of Captain Moncrieff.

Taking the calculation and experiments on the strength of the cone-screw as a base, we may safely say, that this breech-loading mechanism may be advantageously applied to every old cast-iron cannon, converted according to Major Palliser's system; and that cast-iron new guns, cast on Rodman's principle, with core right through, lined with Major Palliser's coil tube, and having this cone-screw as a closing for the breech as described, would be at the same time very cheap, strong, and give quick firing.

In conclusion, it is contended that the breech-loading mechanism, as just described, will find ample application, because of its strength, sim-

plicity, and ease of manipulation, and last, but not least, because the whole mechanism is entirely exposed to view each time of loading.

The CHAIRMAN: Is the base of the cartridge of metal or of pasteboard?

Mr. JENSEN: Of pasteboard. There is a brass plate as well. The cartridge is made on exactly the same principle as those in use at Woolwich.

Captain BURGESS: Is the brass-plate blown away with the cartridge?

Mr. JENSEN: It is blown away with the cartridge, I believe; but upon that point I must confess I am not quite at home; only I know this much, that Mr. Steenstrüp recommends exactly the same cartridge, with a disc on it, as is now used at Woolwich.

The CHAIRMAN: Can the breech-screw be easily worked?

Mr. JENSEN: Very easily. Only knock out this pin (showing the process with the model) and it is done. I have already shown the utility of the breech-piece. It is one entire piece. It has a screw here, which corresponds with this nut, and the whole is moved by a lever. On pushing the breech-piece in, and giving it a turn and a half with the lever, the breech is entirely closed. If at any time the breech-piece should jam, there is a contrivance here which puts a powerful leverage on this part, which at once loosens the screw, so that you can unscrew it with the hand. But there is very little or no chance of jamming in consequence of the peculiar form of the thread of the screw. The threads are vertical at the back, instead of being oblique as in the ordinary screw. The consequence is, that the pressure from recoil is carried straight against the back of the thread, instead of being carried in an outward direction, as in the ordinary screw; and thus jamming is prevented. You perceive how easily the breech-piece works. I close the breech with the lever as hard as I can, and yet, by simply giving it a tap, it is so loose that I can unscrew it by hand. The objection to many breech-loading cannon is, that the most important part of the mechanism is never exposed to view, so that dirt may continually accumulate, until at last you come to a dead stop, and you have to apply a very heavy force to get the gun put to rights. But in this gun the whole of the mechanism is exposed to view each time of loading. If there is any dirt, you can wipe it out. For instance, compare it with the cannon that has lately been brought out by Captain Stuart on an extremely simple principle, yet the most vital part of the mechanism is always closed up, namely, the ball which is inside, and any dirt accumulating there would necessitate taking the whole thing to pieces, a process which takes time; whereas here the whole of the mechanism is each time exposed to view. I may add that the Norwegian Government has thought well to adopt this principle, and they are now building some guns on it. As soon as the thing has gone so far that I can lay experiments before you, I shall be most happy to do so.

The CHAIRMAN: Has a gun on this principle been tested by firing?

Mr. JENSEN: I understand Mr. Steenstrüp has made a small cannon, and found it very efficient. But the main thing is to try it on a larger scale, which he is now about to do.

The CHAIRMAN: Perhaps Mr. Forbes will tell us what he knows about the gun.

Mr. FORBES: I did not expect to be called upon at all. There is very little I can say. I know Mr. Steenstrüp personally, and that he is an able mathematican. But this is the first time I have seen the model of the gun itself. I should not, therefore, like to venture an opinion upon it.

Captain BURGESS: I should like to ask how the iron rod, with the conical-screw and nut on the end of it (Fig. 2), was tested. Was the weight of 50 tons dropped or lifted?

Mr. JENSEN: It was lifted by means of a ring resting on the nut. The 50 tons weight broke the rod, as you see. But when it was examined afterwards, it was found that the nut was quite loose, showing that there had been no compression, not sufficient compression on the screw thread to injure it. In fact, you can by induction see that it could not be injured, because if you take a common screw, such as is in use every day, and turn it down to the bottom of the thread, it has been found by experiment that if you have a nut of the same depth as the outside diameter of the thread across here (showing), then that thread

is just as strong as the bolt itself. If that bolt will break with 10 tons, or 50 tons, or whatever the weight may be, it will take as much to strip the screw threads, for they are just as strong. But if you make a cone-screw, you have the whole of these areas very considerably larger in proportion to this smallest area than in this case, so much so, that a cone-screw of the dimensions given there, the strength of these threads together is, I should say, upwards of 50 per cent. more than the strength of such a screw as that, the diameter of the unscrewed part being the same in both cases.

Captain BURGESS: Was the weight applied at once, as a mass of 50 tons, or was it put on gradually?

Mr. JENSEN: It was put on gradually; but, as remarked in the paper, the cone-screw was also tried with blows. Heavy blows with a 100lb. hammer were applied to the top of the screw, tending to force the screw through the nut and injure the threads. Instead of doing that, it did not injure them at all. It flattened the upper thread, as you see. You see that it has been handled very roughly, but the threads in the nut were not in the least injured, so much so, that the nut could be unscrewed by hand afterwards. So this cone screw is just as much stronger than the ordinary screw, as the area of all these threads is larger than the areas of the thread in an ordinary screw. Because if we compare two screws, one with the ordinary thread, the other with the cone thread, the plain or unscrewed part of which is equal to diameter at bottom of the thread at the small end of cone, you can see that the width of thread at its base times the total length or circumference of the same, which constitute the whole of the area exposed to the shearing strain, is very much larger in the cone-screw than it is in the parallel screw. You have the same number of threads here that you have there; but here you have a diameter very much bigger at its largest end than there; consequently, the total thread circumference, and hence the total area exposed to the strain, is so much larger here than it is there. If 50 tons will break that bolt, 50 tons will also break this bolt. But if this nut, for instance, is a little less than the diameter, 50 tons will pull the screw through the nut with the parallel thread; but 50 tons there will not do the conical thread the least harm, because the whole area of these threads is so very much larger than the whole area of all the threads in the parallel screw.

Captain BURGESS: Could you tell us whether Mr. Steenstrüp ever tried letting a weight fall along the bar upon the cone-screw—the weight falling through a certain space. I believe that is how Major Palliser tried his plus-screw. A gradual drawing strain is different from a violent blow.

Mr. JENSEN: Just so; but Mr. Steenstrüp put it to a more severe test than that, because he had a man hammering away at it with a 100 lb. hammer.

Captain BURGESS: I do not mean testing the screw with a hammer, but with a weight of 50 tons falling through space.

Mr. JENSEN: I believe not. But it stands to reason that this screw must be stronger than the ordinary screw, and still stronger than the closing screw in the French gun, in which, you are aware, half the area of the threads is cut away, and therefore you lose half the strength, and you must make up for that by making the screw so much longer, whereas here you can do with a very short screw, because it is so immensely strong.

Captain BURGESS: May I ask what is the difference in length of the threads in the cone-screw and those of an ordinary longitudinal screw?

Mr. JENSEN: I do not know exactly; but I should say nearly double the area and double the strength. The easiest way to get it is to take the mean of the diameter in the middle of the length of the screw, here and there. I should judge this diameter is very nearly double that diameter, but really I think that the cone-screw is shown longer on the drawings than there is any occasion for, because the strength of it is so much greater than the strength of the straight screw.

Captain BURGESS: The plan of grooving the cradle for carrying the shot appears to me exceedingly ingenious, because the shot finds its groove in the gun at once.

Mr. STEPHEN: Will you kindly show the revolution of the lever in closing the screw. You have shown it once, but I do not think it is quite understood. Your hand appeared to take more than one turn.

Mr. JENSEN: No. You see this handle now stands horizontally. That is one turn, and that is half a turn (showing). In closing the gun, one turn and a half is required. Of course, the form may be varied. The cone of the screw may not be at all times exactly like that. It may be varied according to circumstances. In a very large cannon, I should think it would be advisable to have it somewhat more conical, so as to make it work more easily; whereas, in a small cannon, the screw might be very much more straight, and still work so easily that one can have perfect control over it.

The CHAIRMAN: Can the pin that attaches the breech-piece to the cannon be taken out by hand?

Mr. JENSEN: No; I do not think it ought to be so easily taken out as that, because it would be liable to fall out.

The CHAIRMAN: But supposing, in case of a retreat, you have to leave a gun, by taking that breech-piece away, you would disable it.

Mr. JENSEN: Certainly. That, no doubt, may be made so as to unscrew in a moment. That is a point which, of course, can be carried out in many different ways.

The CHAIRMAN: I have seen a similar arrangement in another gun. The men take the breech-piece with them, and the tube is of no use to the enemy.

Mr. STEPHEN: I think there can be no doubt with regard to the strength of the sectional area of the threads. That is an established fact by Whitworth; that is the rude principle upon which he established his measurements. But those are with the double-bevilled screw, while these have one flat side. Do you consider that gives additional strength, or does it only prevent the tightening by the concussion? Has it an advantage beyond that? I quite see that it does away with tightening by concussion; but has it any farther advantage than that? Do you think it adds at all to the strength of the screw?

Mr. JENSEN: No; I do not think it adds at all to the strength; it makes no difference at all. As long as you have the same strength across from here to there (pointing to the base of the thread) as you have from here to there, it matters not at all whether you have both sides conical, or one side conical and the other straight, or have a square thread. It all depends upon the width of base. In some cases I think Mr. Steenstrüp proposes to have square threads.

Mr. STEPHEN: He could give them all the same depth at the back, and half in the front.

Mr. JENSEN: Instead of making them go off to a sharp edge there, he might make them more like that (showing on the black board), with a flat or rounding at the apex.

The CHAIRMAN: Then would he not lose a certain area?

Mr. JENSEN: He would lose that area there; but I think he might take some of the point off, because it is not very advisable to have them come up to a sharp edge, because they might be damaged if anything knocked against them. I do not know that I have dwelt upon the point of the strength of the gun. If you compare that kind of jointing the coils, as shown at *a a*, Fig. 1, you see that there is really no junction at all, because each coil is independent of the other; there is no cohesion between them. If you compare that with this mode of joining, as shown at *i i i i*, Fig. 1, you will see that the whole of the gun is tied together so powerfully that it forms one mass, whereas in that, each piece is independent of the other.

Captain BURGESS: In the Woolwich guns I believe the coils are hooked over one another. They do not simply abut one against another.

Mr. JENSEN: Yes, they are; but it does not give any better joint. They are hooked one over the other, in that way (showing); but I do not see how you can get a good joint unless you screw them together. The whole process is to heat one coil when you want to put it on, and just push it up against the adjoining coil: all the junction you get is just none at all, because if there is no screw to the joint, there is no joint at all, especially if the subsequent contraction on cooling draws them asunder. It gives a certain amount of weakness, which, as mentioned in the paper, may be well enough to some extent, to prevent vibration, but certainly at the expense of strength and cohesion. One would think that Mr. Steenstrüp's mode of joining

would be very much stronger. With the conical screw, all you have to do is to turn it a turn, or a turn and a half, according to the cone you have, and that can be done so quickly that it can take place before the coils get at all cool. If you join them together with a straight screw, you would have to turn it half a dozen times before you could get it joined thoroughly, whereas here it is done in a moment. The coils are heated; they contract when cold, and fit the core tight. If you shrink one coil upon another, and you put it in the lathe and turn it, you cannot see the joint; it is so tight that you can only, by getting it up with a very fine surface, detect that it consists of two pieces. I mean, supposing that to be a section of one coil shrunk upon the other, if you were to turn that in the lathe, you cannot see that line at all; it shows like one mass; it is only by polishing it up that you can at all detect that there is a joint. So the system of shrinking it on makes it very tight, indeed it forms like one mass.

Captain Burgess: I wish to mention that when Mr. Steenstrüp, who is the Chief Engineer of the Royal Norwegian Navy, was over here, he showed me several letters from the manager and foremen in Sir William Armstrong's works at Elswick; they spoke in high terms of the cone-screw.

Mr. Jensen: He showed me the same, and they certainly spoke of it in the highest terms. He had some from the manager, and some from the foremen, and they all said they had never seen anything like it. The simplicity of it, the strength of it, and the thorough workman-like and mechanical way in which the principle was carried out, was something they had never seen before; and they were Sir William Armstrong's people.

The Chairman: Is the shape of the thread of the screw novel?

Mr. Jensen: This system of cone-screw is not new; it has been known for years. But the novelty in this case is its application in this particular way. It so happens that now-a-days very few things are entirely new. But it is new so far as to be a novel application, and a novel combination of mechanical parts, each of which may have been know before.

The Chairman: The guns with the cone-screw breech have not been tested on a large scale yet?

Mr. Jensen: Not yet. The Norwegian Government are making several guns, and I hope to be able to give you the results of experiments in due time. But the matter moves very slowly. I understand from Mr. Steenstrüp that it has to go through Committees; and money is not so plentiful there as it ought to be in such matters. Things are done economically and slowly; consequently he is not so well situated as he would be in this country.

The Chairman: We are very much obliged to you, Mr. Jensen, for the explanation you have given us of this invention, and I beg to convey to you the thanks of the Institution.

Mr. Jensen: Allow me to thank you very sincerely for the very kind compliment you have paid me. You will be pleased to remember that my part is very small indeed. I have translated the paper, and tried to explain it in the best way I could. I shall have much pleasure in telling Mr. Steenstrüp of the very courteous and polite way in which his paper has been listened to.

The Chairman: You will communicate to Mr. Steenstrüp how much obliged we are to him for the paper you have read?

Mr. Jensen: With pleasure.